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EVALUATION OF LOW-SULFUR WESTERN COAL CHARACTERISTICS, UTILIZATION, AND COMBUSTION EXPERIENCE

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EVALUATION OF LOW-SULFUR WESTERN COAL CHARACTERISTICS, UTILIZATION, AND COMBUSTION EXPERIENCE

by

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ABSTRACT

This report summarizes the data on western coal statistics, combustion, and mining. Detailed information is presented for coal occurrence, production, composition, and physical and chemical properties. Discussions and economic analyses are given as to the available mining techniques and transportation modes to bring these vast coal reserves to large fuel combustion markets. The effects of western coal properties on combustion equipment operation and emissions to the atmosphere are evaluated. The overall impact of increased western coal production on the environment is also analyzed and recommendations are made for further investigation of problematic areas.

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SECTION 1

CONCLUSIONS AND RECOMMENDATIONS

1. The western states considered in this report and having the greatest amount of demonstrated coal reserves in decreasing order of tonnage are: Montana, Wyoming, North Dakota, New Mexico, Colorado, Washington, South Dakota, Arizona, Utah, and Oregon. Over 200 billion tons of coal reserves have been demonstrated in these states which represents more than 46% of the total demonstrated coal reserves in the United States.

2. From over 200 billion tons of demonstrated coal reserves in the western states, over 43% are surface minable.

3. In terms of estimated coal reserves in the United States, the western states account for about 16% of bituminous coal, 81% of sub-bituminous coal, and 98% of lignite. The anthracite deposits are negligible (less than 1%).

4. Eighty percent of sub-bituminous estimated coal reserves and 91% of lignite estimated reserves in the western states contain less than 1% sulfur.

5. The lowest rank coal, lignite, is generally found in western North Dakota and part of eastern Montana. The highest rank surface coal is found in the Southwest

portions of Arizona and New Mexico. The highest rank underground coal occurs in Utah and Colorado.

6. Coal mining operations in the West are mechanized to a high degree due to the shortage of skilled labor. The operations are also very large and efficient and usually exceed U.S. average tonnage output per man per shift in both underground and surface mines.

7. Typical mining operations in the West use either underground or surface mining methods. Horizontal auger mining is less common but is gaining acceptance because it can recover the large amounts of coal left in strip mine high walls.

8. Underground or deep mining is used in the West to extract the higher quality bituminous coals such as those used in coke manufacturing. The production of underground mines is executed in one of two ways: the traditional room-and-pillar system or the newer longwall system.

9. Of the two basic methods of surface mining practiced in the U.S., contour mining is less applicable to the relatively flat or gently rolling topography of the West. Area mining is the major strip mining method used on western coal lands. Flat open pits developed may range 100 feet wide and 1 mile long.

10. Underground coal mining costs usually center around labor issues because of the large number of persons required. Strip mining is largely equipment intensive

(about 74% of the capital investment costs). Relatively large capital costs of underground pit development is eliminated by strip mining. Despite the high cost per ton of underground coal, the underground mines can be competitive with strip mines on a cost per Btu basis. Presently, the large transportation costs to deliver western coals to the major market areas are offset at the mine by low overburden-to-coal ratio. The mining becomes impractical technically if the overburden thickness is more than about 200 feet.

11. Approximately 10% of the total U.S. coal resources lie within 150 ft of the surface (maximum economic and practical stripping depth). This precludes strip mining from a major role in the ultimate recovery of American coal. In the long range the re-emergence of underground mining methods may be expected. Significant factors inhibiting the development of new western coal mines today are legislative uncertanties, high cost of meeting stringent reclamation requirements, new mining equipment availability, long haul transportation economics, skilled manpower shortage, lack of new mining technology utilization, and high capital investment.

12. A total of 109 coal mines produced nearly 58 million tons of bituminous, sub-bituminous and lignite coals marketed in the West in 1973. Their production amounted to about 30 thousandths of 1% of demonstrated coal reserves in the western states. Eighty-two percent of

this production came from surface mines. Wyoming is the leading state in the western coal production followed by Montana and New Mexico. Almost 14 million tons were produced in the state of Wyoming in 1973. Montana produced almost 10 million and New Mexico produced over 9 million tons in the same year.

13. The western states coal production estimates indicate that the production will increase about 8.6 times between 1972 and 1985.

14. Approximately 70% of the western coal produced stayed in western producing districts.

15. F.O.B. mine prices of surface mined coal in the West varied from $2.00 to $8.00 per ton in 1972, compared to the U.S. average of $5.48 per ton. The cost of underground coal ranged from $4.89 to $16.40 per ton with the U.S. average at $9.70 per ton.

16. Approximately 21% of western coal production in 1972 was mechanically cleaned.

17. Although production of western coals is expected to increase rapidly, it will be very dependent on presently uncertain strip mining legislation.

18. The scarcity of water in most portions of the West dictates that ground water be used to provide water for coal mining and transporting. The Westwide Water Study conducted by the Department of the Interior

promises to generate a detailed information plan on future water requirements in the West. The study will be completed in 1977.

19. Considering overall ranges for coal properties, the western coals are in the medium range of volatile matter, in the lower range for fixed carbon, in the higher range for moisture content, in the lower range for caloric values, and the lower range of sulfur content. Western coal deposits contain coals with low as well as high ash contents.

20. Comparison of ash compositions in western coals and eastern coals reveal that low sulfur-containing western coals are also low in iron. However, generally higher SO_3 content in the ash is observed with western coals (Refer to Table 28). The western coals are also 2 to 4 times higher in average calcium and magnesium, and 2 to 8 times lower in average potassium content. Sodium content does not seem to follow any particular trend, with the exception of North Dakota and Montana coals which have relatively high sodium content of 4.4% and 2.8%, respectively. Other U.S. coals range in average sodium content between 0.1 and 1.7% as Na_2O.

21. Total trace element content in western coals is nearly the same as in other coals of the United States, but the distribution of each element differs. Cadmium and selenium are indigenous only to western coals.

22. Rail methods comprising unit trains and common carriers are currently the prime movers of western coal. Rail rates up to 4.5¢ per ton-mile are currently paid for rail movement. Combined rail/water transport and coal slurry pipelines appear most promising for large-scale movements of western coal to the eastern markets. The existing rail system in the West could not handle increased coal haulage without substantial modernization and upgrading.

23. Based on a study performed in 1971 (refer to section 3.6.1), the cheapest means of western coal transporting is by integral train, followed by coal slurry pipeline and coal transport by shuttle train. Any of these three transportation techniques is between 24-67% cheaper than the western states' 1964 transportation cost average for long haul distances such as 900 miles. (See Figure 39).

24. The best market potential for western coal based upon local rail coal transportation is determined to be in the northeast central and northwest central regions (see Table 34).

25. Water transport of western coal is not significant due to the lack of navigable rivers. Combined rail-river and rail/Great Lakes transportation is forecasted to play an increasingly important role in the expnasion of western coal utilization.

26. The coal slurry pipeline is a proven coal transport method. A 273 mile line hauling 5 1/2 million tons of coal per year is being successfully operated by Black Mesa Pipeline, Inc. Additional pipeline projects are currently under study.

27. Considering the boiler steam capacity range between 10,000-500,000 lb/hr, the underfeed stockers are predominant in 10,000-100,000 lb/hr range, the spreader stokers in 100,000-250,000 lb/hr range, and the pulverized coal firing in 250,000-500,000 lb/hr range.

28. In most instances firing western coals in these boilers designed for eastern or midwestern coals would result in an increased carbon loss. Some derating of the boiler capacity would also be needed for units presently operating at full capacity.

29. Comparison of operation attributes rated the three most widely used stokers in the following descending order

-spreader
-chain and traveling grate
-underfeed

The traveling grate type was preferred over the agitating grate type for all three stokers.

30. Both fire-tube and water-tube boilers are utilized up to 22,000 lb steam/hour boiler capacity. Only water-tube boilers are used above this capacity.

31. Boiler fouling rate increases rapidly with increasing sodium content of ash at low sodium contents. The fouling levels off when sodium content of ash reaches 8-10%. High calcium contents reduce the effect of sodium on the deposition mechanism. To minimize fouling requires reducing sodium content of ash to levels as low as 1%.

32. No effect on boiler fouling rate was observed with changes in the fuel moisture content and the percentage of excess air. Fouling rate was increased markedly with increasing temperature, especially between 800 and 1200°F, and 1800 and 2100°F.

33. Corrosion of the boiler tubes on the fire side is not fully understood, but several chemical reaction mechanisms have been proposed.

34. Firing of western coal in equipment designed to burn eastern or midwestern coal resulted in reduction of boiler capacity due to western coal's lower heating value and lower density. Existing coal feeding mechanisms designed for more dense and higher quality coal were the reasons for this reduction. A decline in the collection efficiency of electrostatic precipitators was also observed as a result of western coal's low sulfur content and subsequent high fly ash resistivity. Ash high sodium content and operation of electrostatic precipitator at elevated temperature (425°F) increase the fly ash resistivity to levels comparable with those for high sulfur coal. High coal moisture content will also reduce boiler efficiency.

35. The fractions of state land areas that may potentially be disturbed by coal mining in the western states are generally orders of magnitude smaller than the fractions observed in non-western states.

36. Full reclamation of land in strip mined areas of the West is expensive and has been practiced to some extent with mixed success. Most serious problems include backfill of huge mined-out pits, topsoil replacement, and revegetation in these semi-arid and arid regions. Longwall stripping is a promising new surface mining concept resulting in minimum damage of the environment and the soil surface.

37. Hazardous emissions of the particulates accompany coal mining operations. Additional airborne particulates and noxious gases are emitted from wind erosion and self-igniting refuse piles. Presently, these emissions are not well documented and technology for their control is not generally available.

38. There is insufficient information to assess the effect of western coal trace element composition on the environment. Additional work to investigate the form and fate of these elements in the environment as well as their hazard potential is urgently needed.

39. The low-sulfur emissions characteristics of western coals are penalized by their lower heating values. That is, more western coal must be burned to maintain the same boiler heat rate obtained with non-western

coal. However, available data indicate that low-sulfur western coal burning plants in the small and intermediate boiler size range examined generally meet the Federal SO_2 regulation (1.2 lb SO_2 per 10^6 Btu). None of the non-western coal burning plants examined which burned high-sulfur high heating value coals met the SO_2 emission regulation.

40. As coal sulfur content decreases increased sulfur retention in the coal ash becomes important in reducing SO_x emissions. Western coals characteristically appear to retain more sulfur in ash (27% max as SO_3) than their nonwestern counterparts (10% max as SO_3). This is in part due to the higher alkalinity of western coal ash.

41. Whether or not a specific coal meets the SO_2 emission standard depends on coal heating value, coal ash content, coal sulfur content and the previously mentioned sulfur content of the ash after combustion. A relationship comprised of the above variables which could be used to define the minimum sulfur retention in the coal ash in order for the coal to meet the sulfur emission standard is proposed for verification.

SECTION 2

INTRODUCTION

One of the potential means of sulfur oxides emission control from combustion sources is the use of low sulfur fuels. Vast reserves of coal with large portions containing permissible sulfur levels occur in western parts of the United States. These coal deposits are often easily accessible and subject to strip mining, but usually have low heat content, and high ash and water contents. Other properties such as ash fusion temperature, trace element contents and Hardgrove grindability index also have important effects on combustion processes, efficiency of combustion equipment, and properties of combustion gases emitted to the atmosphere.

In order to better define the technical, economic, and environmental problems that may arise should an extensive utilization of western coal reserves occur, the Environmental Protection Agency contracted with Monsanto Research Corporation to conduct this study. The objectives of the study were to summarize present experience in the combustion of western coals, catalog their occurrence and properties, and identify potential problematic areas in bringing these coals to large markets. This report documents the results of the study.

After the summary of findings and recommendations in the previous section, the report presents data on utilization of western coal in Section 3. This section includes information on western coal reserves and resources, mining technology, production and consumption, composition, factors influencing mining, and transportation. Section 4 evaluates western coal combustion and Section 5 presents information on the environmental effects associated with western coal mining and combustion.

SECTION 3

WESTERN COAL UTILIZATION

3.1 RESERVES AND RESOURCES

This report covers the ten states listed below which are deemed important to the development of western coal production:

- Arizona
- Colorado
- Montana
- New Mexico
- North Dakota
- Oregon
- South Dakota
- Utah
- Washington
- Wyoming

Although Oregon and South Dakota have the least coal in terms of potentially minable reserves, they are included for completeness.

The following nine western states are not considered important for fundamental coal development due to a lack of resources, high sulfur content, or uneconomical distance of hauling to midwestern markets:

- Alaska
- California
- Idaho
- Kansas
- Missouri
- Nebraska
- Nevada
- Oklahoma
- Texas

Table 1 gives some indication of the relative merits of the considered states from a low sulfur standpoint. The arrows on Table 1 point to the ten states included in the study. A majority of sub-bituminous coal and lignite with 0.7% or less sulfur is contained in these states.

Figure 1 shows the major coal regions of the western states. The nomenclature of these coal regions is defined in Figure 2. Table 2 shows that over 200 billion tons of potentially minable coal occur in the ten western states considered in this report. Of this quantity, 87 billion tons are considered surface minable and 114 billion tons are considered minable by underground methods. The state-by-state ranking in decreasing order of demonstrated reserve tonnage in millions of short tons is as follows: 1) Montana (107,727, 2) Wyoming (51,228), 3) North Dakota (16,003), 4) Colorado (14,870), 5) New Mexico (4,394), 6) Utah (4,042), 7) Washington (1,954), 8) South Dakota (428), 9) Arizona (350), and 10) Oregon (1). Over 46% of the entire U.S. reserve base is located in the 10 states included in this study.

A coal reserve differs from a coal resource. Coal reserves represent calculated, potentially minable tonnages, whereas coal resources represent total in-place tonnages of coal. All coal resources may not be presently considered minable due to some physical restrictions such as thin seams.

Thickness criteria used by the Bureau of Mines to compute the reserve values given in Table 2 are 28 inches or more for bituminous coal and anthracite, and 60 inches or more for subbituminous coal and lignite. The maximum depth for

Table 1. ESTIMATED REMAINING COAL RESERVES OF THE UNITED STATES BY RANK SULFUR CONTENT, AND STATE, ON JANUARY 1, 1965[1]

(Million short tons)

Rank & State	Sulfur content, percent									Total
	0.7 or less	0.8-1.0	1.1-1.5	1.6-2.0	2.1-2.5	2.6-3.0	3.1-3.5	3.6-4.0	Over 4.0	
Bituminous coal:										
Alabama	889.2	1,169.3	5,421.7	5,182.0	458.8	417.4	---	---	18.4	13,577.8
Alaska	20,287.6	1,100.0	---	---	---	---	---	---	---	21,387.6
Arkansas	---	---	1,128.4	293.1	154.0	---	40.3	---	---	1,615.8
Colorado	25,178.3	37,247.2	---	---	---	---	---	---	---	62,425.5
Georgia	---	76.0	---	---	---	---	---	---	---	76.0
Illinois	---	579.7	4,882.4	2,615.1	889.6	16,583.8	11,650.4	97,652.2	19,562.0	135,889.2
Indiana	197.5	173.0	3,645.2	4,248.8	3,543.4	4,110.5	10,272.0	5,105.9	2,944.0	34,841.1
Iowa	---	---	---	---	---	---	117.1	---	6,405.4	6,522.5
Kansas	---	---	519.9	519.7	1,030.7	2,070.6	4,148.0	8,287.1	4,253.8	20,738.0
Kentucky:										
West	---	---	1,119.6	162.0	336.3	3,793.6	17,759.3	13,649.8	5,081.3	38,895.4
East	12,619.9	8,501.9	7,286.0	1,650.8	1,150.3	2,154.4	24.7	---	---	29,414.8
Maryland	---	---	---	124.6	191.8	308.2	378.6	56.4	220.4	1,280.0
Michigan	---	---	---	---	---	---	---	205.0	---	205.0
Missouri	---	---	---	---	---	---	4,456.7	20,669.2	51,636.1	78,740.0
Montana	71.0	218.2	205.0	397.2	400.0	175.0	40.0	77.0	501.0	2,104.6
New Mexico	5,212.0	5,474.0	---	---	---	---	---	---	---	10,686.0
North Carolina	---	---	---	---	---	110.0	---	---	---	110.0
Ohio	---	611.0	866.0	2,110.2	2,750.4	7,810.5	9,785.3	10,148.2	8,439.4	41,024.0
Oklahoma	290.6	777.2	825.5	968.1	---	---	577.2	19.2	490.6	3,302.8
Oregon	---	14.0	---	---	---	---	---	---	---	14.0
Pennsylvania	44.0	1,154.4	7,624.6	17,474.9	19,689.5	9,997.6	5,287.6	1,155.5	580.6	57,951.5
Tennessee	7.3	203.9	715.9	258.7	128.2	350.5	219.7	43.6	68.5	1,939.5
Texas	---	---	---	---	7,978.0	---	---	---	---	7,978.0
Utah	8,851.4	13,584.0	---	1,524.9	---	---	---	---	3,957.7	27,118.0
Virginia	6,971.5	5,077.5	1,437.1	---	171.9	---	---	---	---	9,520.0
Washington	806.9	672.1	---	---	---	---	---	---	---	1,571.0
West Virginia	25,791.0	36,718.6	21,819.7	13,290.6	8,496.1	2,891.8	3,147.4	5,949.2	---	152,666.4
Wyoming	6,202.2	6,598.6	---	---	---	---	---	---	1.1	12,719.9
Other States[2]	---	416.0	---	---	---	---	---	---	---	416.0
Total	105,375.4	111,932.8	52,268.2	45,179.5	47,307.0	50,111.3	87,000.1	122,957.1	103,888.1	724,687.2
Percent of total	14.4	15.6	7.2	6.2	6.5	6.9	12.1	17.3	14.3	100.0
Subbituminous coal:										
Alaska	71,115.6	---	---	---	---	---	---	---	---	71,115.6
Colorado	13,320.8	4,906.7	---	---	---	---	---	---	---	18,227.5
Montana	96,384.1	34,728.6	3.5	1,003.7	---	---	---	---	---	132,119.6
New Mexico	38,735.0	11,990.0	---	---	---	---	---	---	---	50,725.0
Oregon	87.0	87.0	---	---	---	---	---	---	---	174.0
Utah	---	---	150.0	---	---	---	---	---	---	150.0
Washington	3,693.8	500.0	---	---	---	---	---	---	---	4,193.8
Wyoming	35,676.9	71,315.6	---	---	---	---	---	---	8.4	107,001.9
Other States[3]	---	2,097.0	---	---	---	---	---	---	---	2,097.0
Total	258,834.5	130,146.7	158.5	1,003.7	---	---	---	---	8.4	388,665.4
Percent of total	66.6	33.4	0.1	0.3	---	---	---	---	(3)	100.0
Lignite:										
Alabama	---	---	20.0	---	---	---	---	---	---	20.0
Arkansas	280.0	70.0	---	---	---	---	---	---	---	350.0
Montana	61,019.6	24,141.6	2,660.5	---	---	---	---	---	---	87,821.7
North Dakota	284,127.1	54,487.0	11,592.4	---	---	464.7	---	---	---	350,671.6
South Dakota	---	2,031.0	---	---	---	---	---	---	---	2,031.0
Texas	---	---	6,902.0	---	---	---	---	---	---	6,902.0
Washington	---	116.4	---	---	---	---	---	---	---	116.4
Other States[4]	---	42.0	---	---	---	---	---	---	---	42.0
Total	345,426.7	81,188.5	21,174.9	---	---	464.7	---	---	---	447,541.1
Percent of total	77.2	18.1	4.7	---	---	0.1	---	---	---	100.0
Anthracite:										
Alaska	1,178.7	---	---	---	---	---	---	---	---	1,152.0
Arkansas	---	---	---	145.5	286.3	---	---	---	---	431.8
Colorado	---	90.0	---	---	---	---	---	---	---	90.0
New Mexico	---	4.5	---	---	---	---	---	---	---	4.5
Pennsylvania	12,211.0	---	---	---	---	---	---	---	---	12,211.0
Virginia	100.0	---	---	---	---	---	---	---	---	100.0
Washington	5.0	---	---	---	---	---	---	---	---	5.0
Total	14,367.7	94.5	---	145.5	286.3	---	---	---	---	15,174.8
Percent of total	96.1	0.6	---	0.9	2.0	---	---	---	---	100.0
Grand Total	557,465.3	323,362.4	93,575.2	46,328.7	47,593.3	50,576.0	87,585.1	122,957.1	103,897.1	1,556,584.5
Percent of total	41.0	19.3	5.9	3.0	3.0	3.2	5.5	7.8	6.6	100.0

Arizona, California, Idaho, Nebraska, Nevada

Arizona, California, Idaho

Less than 0.1 percent

California, Idaho, Louisiana, Nevada

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[1] Nielsen, G. F. 1971 Keystone Coal Industry Manual. New York, McGraw-Hill, Inc. 1971. p. [illegible]

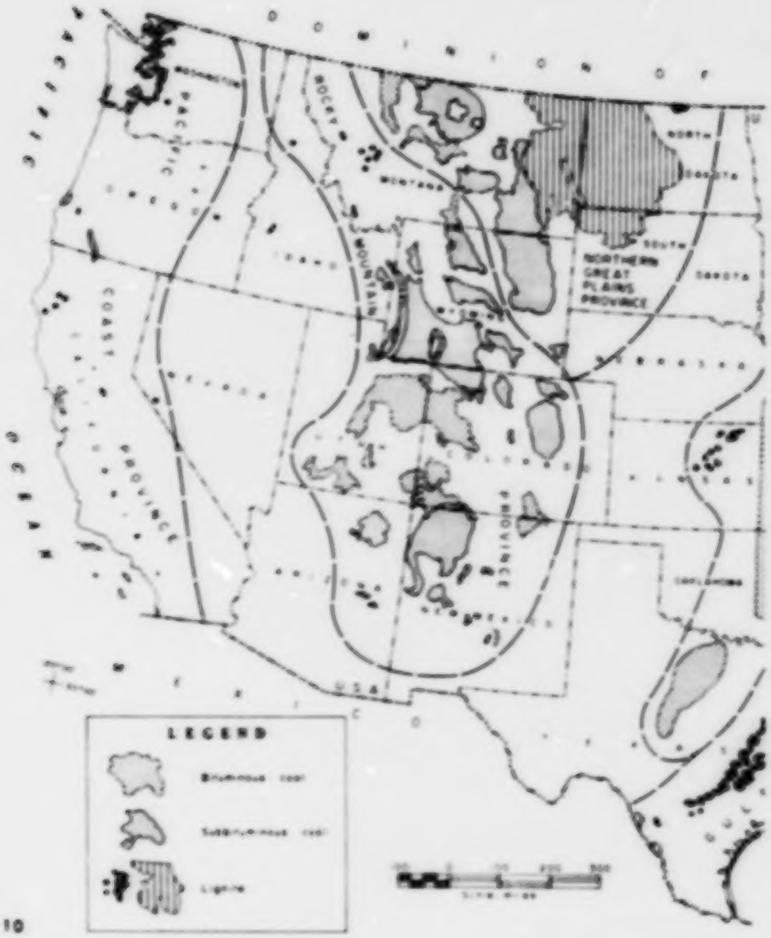
DOMINION OF
PACIFIC OCEAN
PACIFIC COAST PROVINCE
ROCKY MOUNTAIN PROVINCE
NORTHERN GREAT PLAINS PROVINCE
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
MEXICO
USA
LEGEND
Bituminous coal
Subbituminous coal
Lignite
3867-10

Figure 1. Coalfields of the western United States[2]

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[2] Anon. Strippable Reserves of Bituminous Coal and Lignite in the United States. Bureau of Mines Information Circular. 8531. 1971. p. 6.

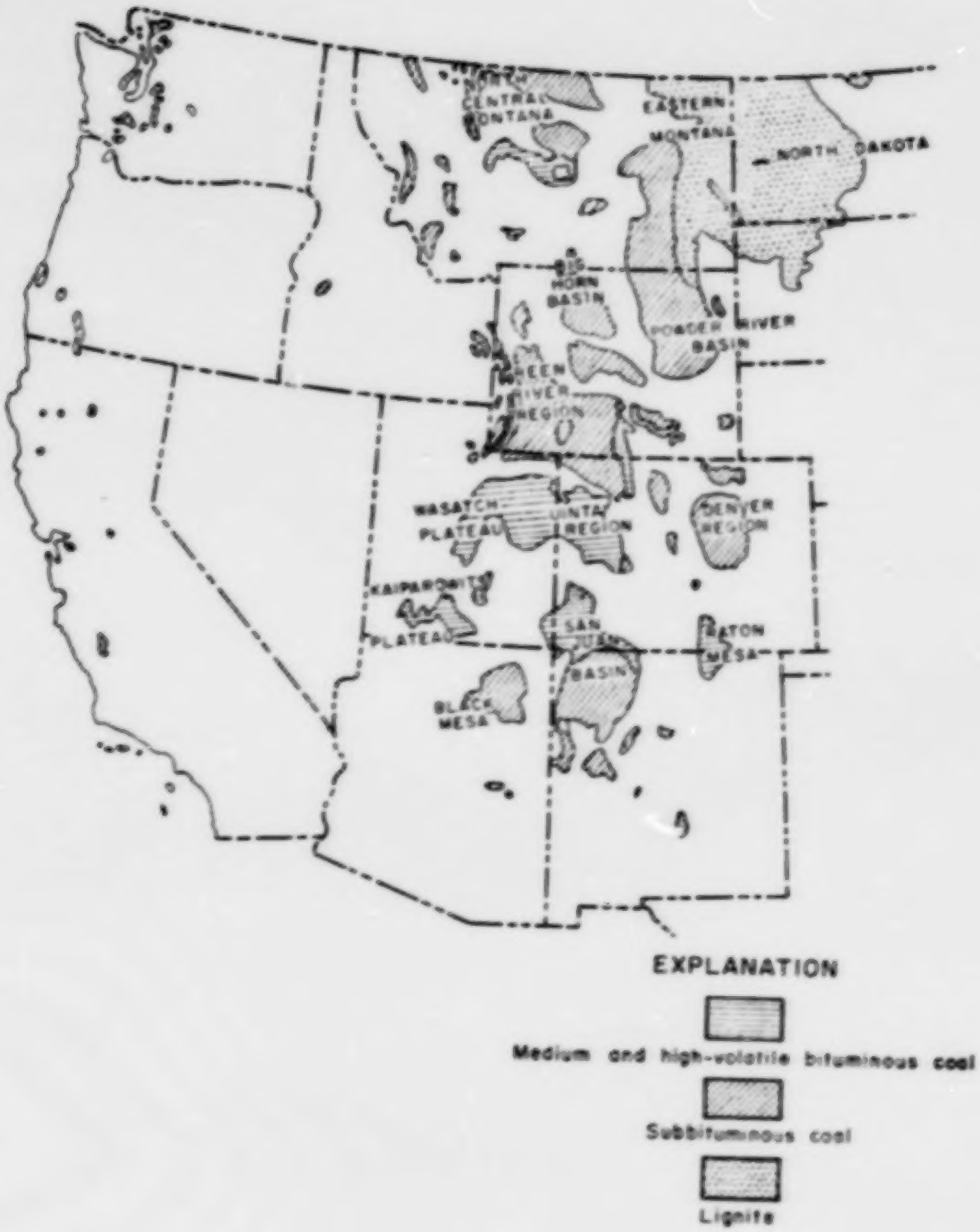
NORTH CENTRAL MONTANA
EASTERN MONTANA
NORTH DAKOTA
HORN BASIN
POWDER RIVER BASIN
GREEN RIVER REGION
WASATCH PLATEAU
UINTA REGION
DENVER REGION
KAIPAROWITS PLATEAU
SAN JUAN BASIN
RATON MESA
BLACK MESA
EXPLANATION
Medium and high-volatile bituminous coal
Subbituminous coal
Lignite

Figure 2. Coal region nomenclature[3]

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[3] Link, J. M., and A. M. Keanan. A Review of the Coal Industry in the Western United States. Colorado School of Mines, Mineral Industries. Bulletin No. 5. 1968. p. 6.

Table 2. DEMONSTRATED COAL RESERVE BASE[a] OF THE WESTERN UNITED STATES ON JANUARY 1, 1974, BY METHOD OF MINING*

(million short tons)

State	Potential mining method		Total
	Underground	Surface[c]	
Arizona	---	350	350
Colorado	14,000	870	14,870
Montana	65,165	42,562	107,727
New Mexico	2,136	2,258	4,394
North Dakota	---	16,003	16,003
Oregon	1	(b)	1
South Dakota	---	428	428
Utah	3,780	262	4,042
Washington	1,446	508	1,954
Wyoming	27,554	23,674	51,228
Total western states	114,082	86,915	200,997
Total U.S.	297,235	136,713	433,948

[a] Includes measured and indicated categories as defined by the USBM and USGS and represents 100% of the coal in-place

[b] Less than 1 million tons

[c] Overburden thickness less than 1000 ft

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*Murphy, Z. E., E. T. Sheridan, and R. E. Harris, Demonstrated Coal Reserve Base of the United States on January 1, 1974. Mineral Industry Surveys. Bureau of Mines Division of Fossil Fuels--Mineral Supply. June 1974. p. 4.

all ranks except lignite is 1000 feet. Lignite reserves are not considered at depths over 120 feet. Currently-mined coal beds which do not meet the above criteria are included in the estimate. Tables 3 and 4 show a further breakdown of these potential reserves by coal rank and by mining method. (Refer to Table 26 for the definition of coal rank.)

The portion of the in-place potential reserves that can be recovered depends on the exact mining methods characteristic to a specific coalfield. The amount of coal that can be recovered generally ranges from 40 to 90%.[4] The low side of this range represents underground mining and the high side represents strip area mining or strip/auger combinations.

Significant changes in the demonstrated coal reserve base can occur. Results of new explorations and mining developments can add to the base, and mining production can decrease it. The demonstrated coal reserve base represents the most accurate estimate available, since it is a compilation of all known deposits. The quality of the reserves reported by the Bureau of Mines and Geological Survey is outlined by the various measured, indicated and inferred categories defined in Table 5.

3.1.1 State Deposits

The following is a brief description of major coal deposits found in the western states. It will become evident that coal tonnages differ in some instances from those shown in Tables 2, 3, and 4. This results because the estimates for the individual states are largely inferred, and those that are calculated have overburden thicknesses over 1000 feet.

Table 3. DEMONSTRATED RESERVE BASE[a] OF COALS IN THE WESTERN UNITED STATES ON JANUARY 1, 1974, POTENTIALLY MINABLE BY UNDERGROUND METHODS[4]
(million short tons)

State	Anthracite	Bituminous	Subbituminous	Lignite	Total
Colorado	28	9,227	4,745	---	14,000
Montana	---	1,384	63,781	---	65,165
New Mexico	2	1,527	607	---	2,136
Oregon	---	---	1	---	1
Utah	---	3,780	---	---	3,780
Washington	---	251	1,195	---	1,446
Wyoming	---	4,524	23,030	---	27,554
Total western U.S.	30	20,693	93,359	---	114,082
Total U.S.	7,294	194,336	97,605	---	297,235

[a] Includes measured and indicated categories as defined by the USBM and USGS and represents 100% of the coal in-place

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[4] p. 5.

Table 4. DEMONSTRATED RESERVE BASE[a] OF COALS IN THE WESTERN UNITED STATES ON JANUARY 1, 1974, POTENTIALLY MINABLE BY SURFACE METHODS[4]
(million short tons)

State	Anthracite	Bituminous	Subbituminous	Lignite	Total
Arizona	---	---	350	---	350
Colorado	---	870	---	---	870
Montana	---	---	35,431	7,131	42,562
New Mexico	---	250	2,008	---	2,258
North Dakota	---	---	---	16,003	16,003
Oregon	---	(b)	(b)	---	(b)
South Dakota	---	---	---	428	428
Utah	---	262	---	---	262
Washington	---	---	500	8	508
Wyoming	---	---	23,674	---	23,674
Total western states	---	1,382	61,963	23,570	86,915
Total U.S.	90	40,561	67,865	28,197	136,713

[a] Includes measured and indicated categories as defined by the USBM and USGS and represents 100% of the coal in-place

[b] Less than 1 million tons

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[4] p. 6.

Table 5. U.S. BUREAU OF MINES CLASSIFICATIONS DEFINING QUALITY OF RESOURCE ESTIMATES[5]

Measured ore. Ore for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are so closely spaced and the geologic character is so well defined that the size, shape, and mineral content are well established. The computed tonnage and grade are judged to be accurate within limits which are stated, and no such limit is judged to differ from the computed tonnage or grade by more than 20 percent.

Indicated ore. Ore for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to outline the ore completely or to establish its grade throughout.

Inferred ore. (a) Ore for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is a geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. Estimates of inferred ore should include a statement of the special limits within which the inferred ore may lie. (b) Used essentially in the same sense as possible ore and extension ore.

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[5] Thrush, P. W. A Dictionary of Mining, Mineral, and Related Terms. Washington, U.S. Department of the Interior, Bureau of Mines. 1968. pp. 575, 578, 688.

More detailed statewide coal resource information as derived from open file and related literature may be found in Appendix A. In all cases the demonstrated coal reserve tonnages (Tables 2, 3 and 4) are the more accurate figures. Figures for estimated resources were included to indicate coal resource potential.

Arizona (350 MMT Demonstrated Reserves)

Arizona's primary known coal deposits are inferred to approximate one billion tons under 130 feet of overburden. These deposits are located in the northeast corner of Arizona under 3200 square miles of Navajo and Hopi Indian Reservation land[1] called the Black Mesa Region. It occupies portions of Navajo, Apache, and Coconino countries (see Figure 3). Other coal bearing areas in the state appear insignificant.

Coal rank is generally considered bituminous but borders on subbituminous (refer to Table 26 for coal rank definition). Variations have been reported ranging on either side of the line that separates subbituminous from bituminous coal. Pierce and Wilt (1970) concluded that the coals of the Black Mesa Field are high-volatile (bituminous).[1] The U.S. Bureau of Mines classed strippable reserves as subbituminous.[1] Nearly all of the Black Mesa coal is unsuitable for coking.

Most of the Black Mesa coal is considered surface minable, but Peirce and Wilt estimate another 20 billion tons may lie within 1700 feet of the surface or less, largely less. How

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[1] pp. 453,453,453.

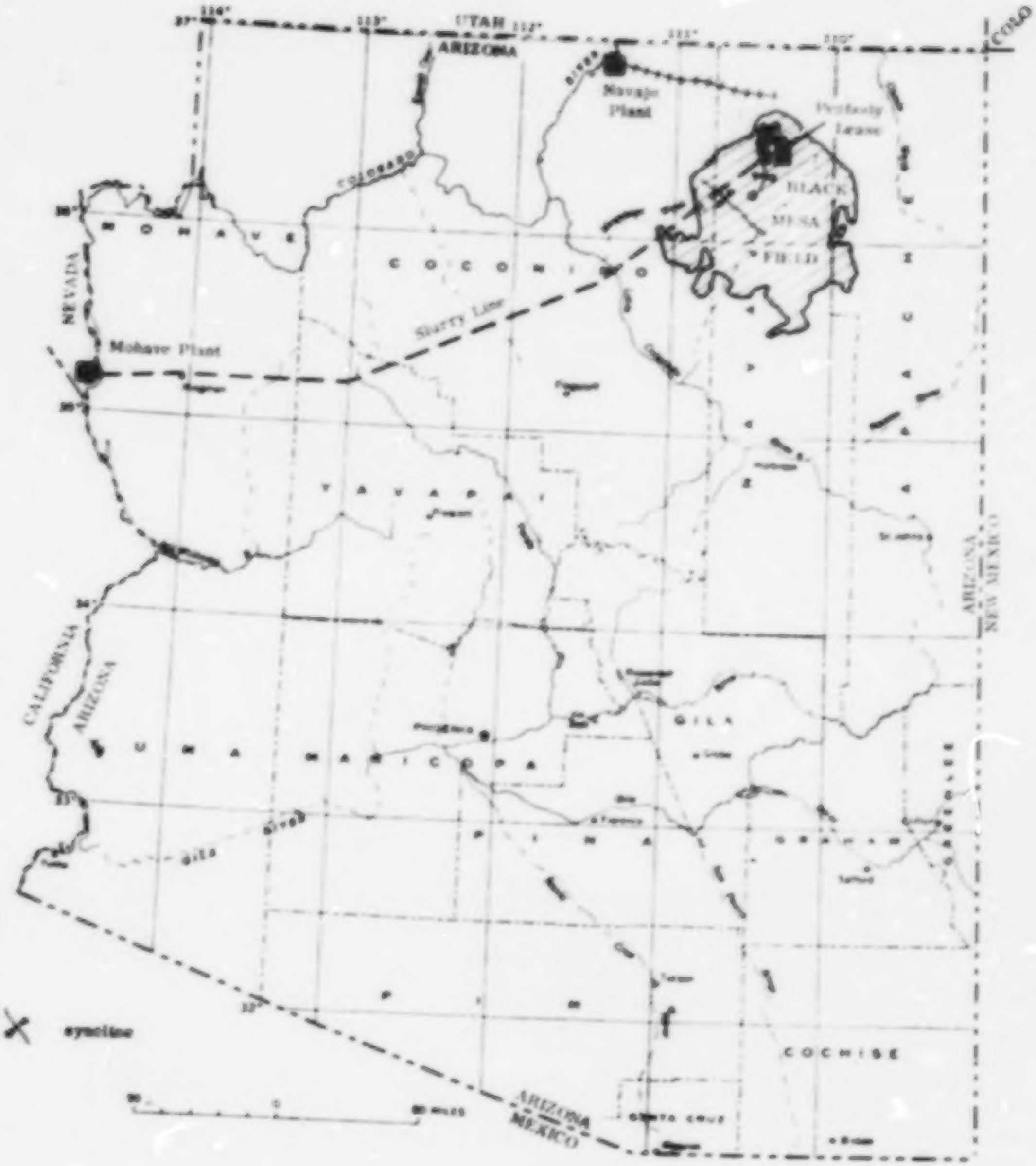
37°
114°
113°
UTAH
ARIZONA
112°
111°
110°
COLO
RIVER
Navajo Plant
Peabody Lease
BLACK MESA FIELD
COLORADO
36°
MOHAVE
COCONINO
NAVAJO
APACHE
NEVADA
Slurry Line
Mohave Plant
35°
YAVAPAI
34°
ARIZONA
NEW MEXICO
CALIFORNIA
ARIZONA
YUMA
MARICOPA
GILA
33°
Gila River
PINAL
GRAHAM
GREENLEE
PIMA
32°
syncline
COCHISE
SANTA CRUZ
ARIZONA
MEXICO

Figure 3. Black Mesa coalfield of Arizona[1]

much of this coal is available for underground mining is unknown. Coal seam thickness ranges from 5 to 28 feet in the surface mineable portions of the field.

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[1] p. 452.

Colorado (14,870 MMT Demonstrated Reserves)

Colorado coal occurs in most parts of the state with the exception of the entire eastern border. Approximately 29,600 square miles in 32 counties is underlain by coal bearing rocks (see Figure 4).[1] A grand total of 230 billion tons of original in-place coal resources is estimated for the 20 major coalfields in the eight coal bearing regions to depths of 6000 feet.[1] These eight regions and 20 coalfields are also identified in Figure 4.

Coal rank ranges from high-volatile B bituminous in the older coal bearing groups of the San Juan Region to subbituminous C and lignite in the younger formations of the Denver Basin and Green River regions. (Refer to Table 26 for coal rank definition.) Some anthracite exists but it is less than 1% of the total resources. It is estimated that half of the Colorado resources are classed as high-volatile bituminous with coking qualities.[6]

About 95% of Colorado's coal resources must be mined underground because of complex structural geology.[1] Folds, faults, and igneous intrusions make conventional surface mining difficult and uneconomical. Underground coal seam thickness varies but can exceed 34 feet in areas of the Uinta Region.

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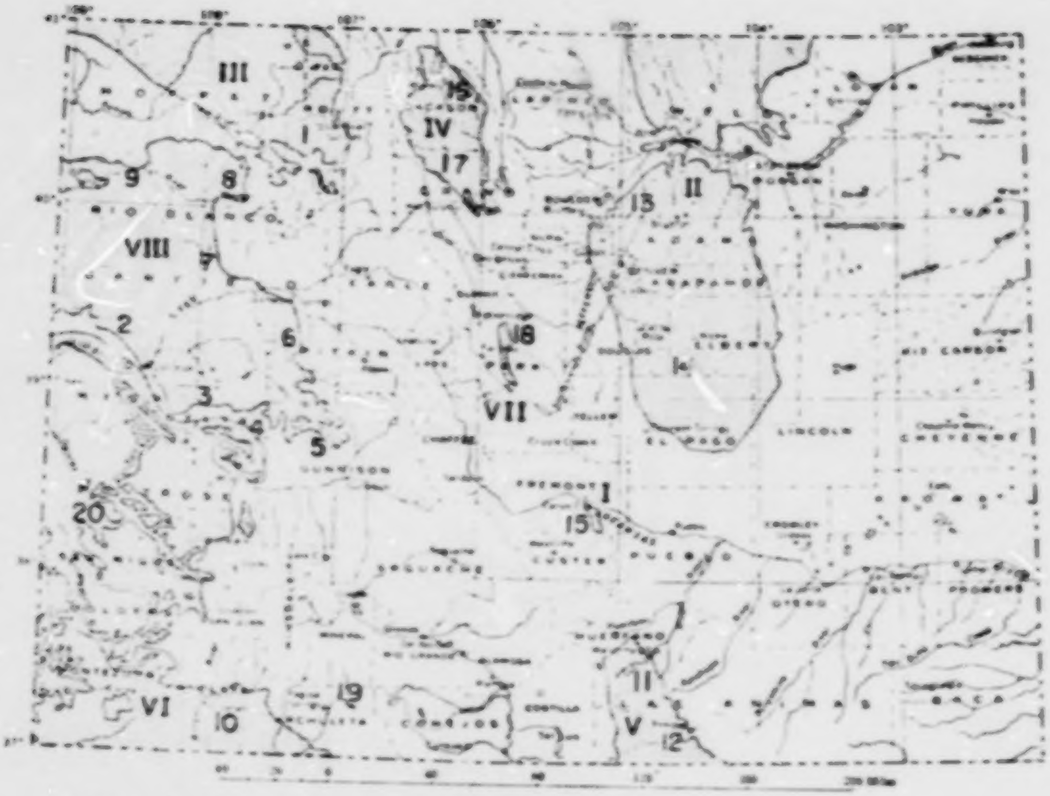
[1] pp. 455, 467, 456.

[6] Robeck, R. C. Colorado: Energy Shortages Prompt New Look at Potential Coal Markets. Coal Age. 79:80, May 1974.



III
16
IV
17
9
8
VIII
7
13
II
2
6
18
14
3
4
VII
5
I
20
15
19
11
VI
10
V
12

COAL REGIONS

I	Canon City
II	Denver Basin
III	Green River
IV	North Park
V	Raton Basin
VI	San Juan
VII	South Park
VIII	Uinta

COAL FIELDS

1. Yampa
2. Book Cliffs
3. Grand Mesa
4. Somerset
5. Crested Butte
6. Carbondale
7. Grand Hogback
8. Danforth Hills
9. Lower White River
10. Durango
11. Walsenburg
12. Trinidad
13. Boulder-Weld
14. Colorado Springs
15. Canon City
16. North Park
17. Middle Park
18. South Park
19. Pagosa Springs
20. Nucla-Naturita

Figure 4. Coalfields of Colorado[1]

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[1] p. 455.

Montana (107,727 MMT Demonstrated Reserves)

Coal bearing areas cover about 35% or 51,500 square miles of the state. Coal resources are thought to be 378 billion tons to depths of 6000 feet.[1] Coal occurs in the 10 regions or fields presented in Figure 5. Subbituminous coal and lignite are the primary types of coal found in Montana. (Refer to Table 26 for coal rank definition.) Bituminous coal also exists in several regions across the state. Vast lignite resources occur in the eastern end, forming part of the North Dakot /Montana lignite regions.

Although there are vast underground reserves, current mining method economics dictate that coal be surface mined. Subbituminous coal resources are currently being mined in the southeastern portion of the Fort Union Region. The state is well known for its thick coal seams. Seam thicknesses of 90 feet and upwards are not uncommon in some areas.[1]

New Mexico (4,394 MMT Demonstrated Reserves)

Coal occurs mainly in the northwestern section of the state. About 25,000 square miles of New Mexico are underlain by coal beds at depths of more than 5000 feet.[1] An estimated 283 billion tons of both surface and deep minable coal resources exist.[1] The regions, areas and fields comprising New Mexico's coal resources are shown in Figure 6.

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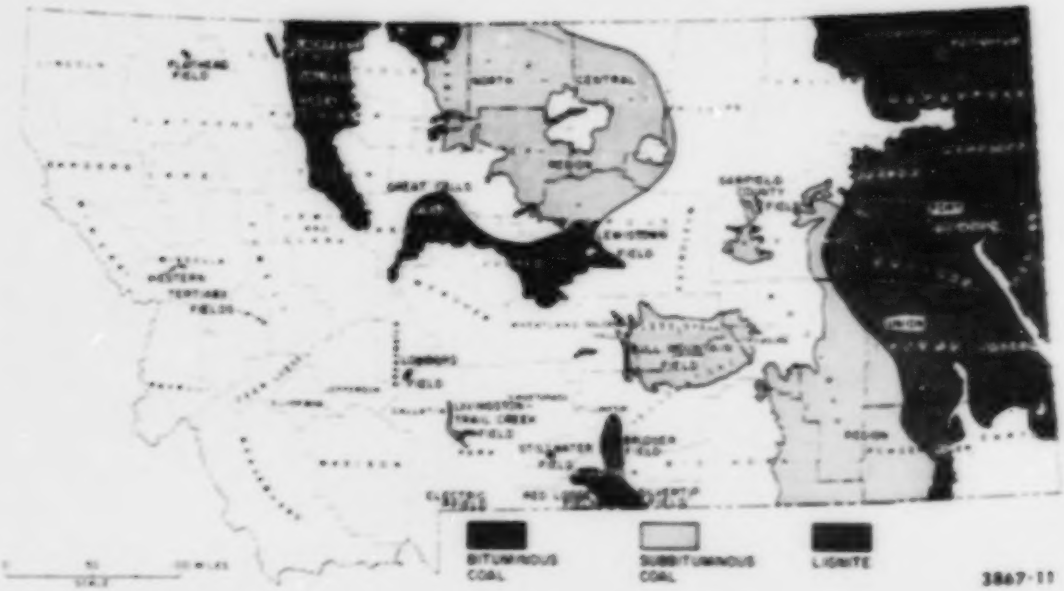
[1] pp. 498, 499, 503, 510.


FLATHEAD FIELD
NORTH
CENTRAL
REGION
GREAT FALLS
LEWISTOWN
FIELD
GARFIELD COUNTY FIELD
WESTERN TERTIARY FIELDS
LOMBARD FIELD
LIVINGSTON-TRAIL CREEK FIELD
STILLWATER FIELD
BRIDGER FIELD
ELECTRIC FIELD
RED LODGE
BULL MOUNTAIN FIELD
UNION
REGION
BITUMINOUS COAL
SUBBITUMINOUS COAL
LIGNITE
SCALE
MILES
3867-11

COAL REGIONS/FIELDS

Fort Union Region
Bull Mountain Field
Red Lodge Field
Great Falls-Lewistown
North Central Region
Blackfeet-Valier Field
Electric Field
Livingston-Trail Creek Field
Lombard Field
Western Region Fields

Figure 5. Coalfields of Montana[1]

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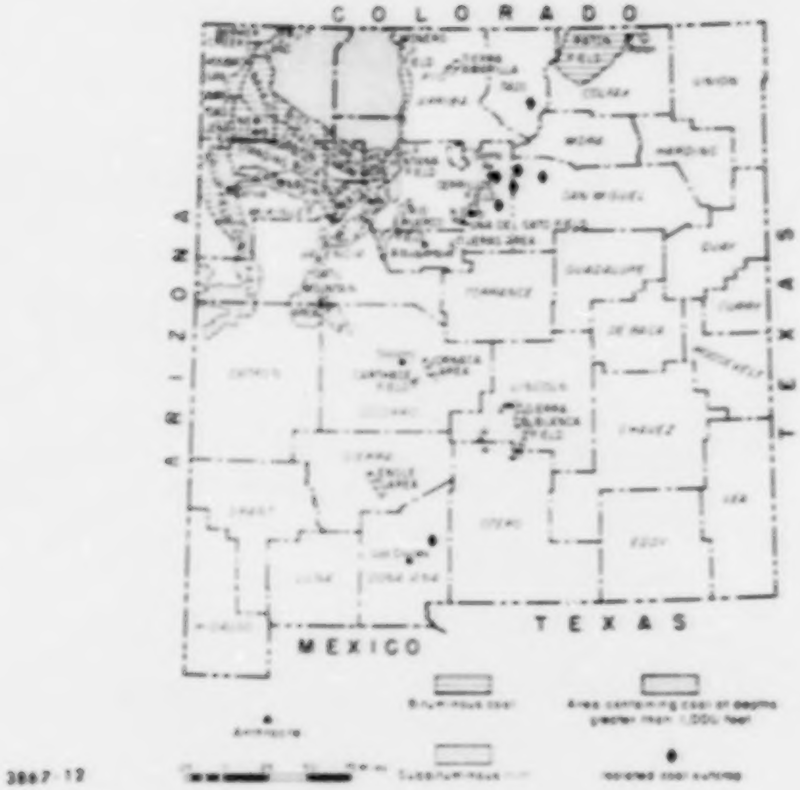
[1] p. 498.


COLORADO
ARIZONA
TEXAS
MEXICO
TEXAS
Anthracite
Bituminous coal
Subbituminous coal
Area containing coal at depths greater than 1,000 feet
Isolated coal outcrop
3867-12

COAL REGIONS/AREAS/FIELDS

San Juan Basin Region
Raton Field
Cerrillos Field
Una del Gato Field
Tijeras Area
Datil Mountain Area
Carthage Field
Jornada del Muerto Area
Sierra Blanca Field
Engle Area

Figure 6. Coalfields of New Mexico[1]

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[1] p. 503.

Coals range from subbituminous B to anthracite in rank, but in general are in the range from subbituminous A to high-volatile C bituminous.[1] (Refer to Table 26 for coal rank definition.) Rank depends primarily on intrusion of igneous rock masses and structural deformation rather than age metamorphism.

Stripping is currently the primary method of mining the coal resources. High quality coking coal in the Raton Field area is encouraging underground activity. Strippable coal seams upwards of 50 feet thick occur in the San Juan Basin Region.[1]

North Dakota (16,003 MMT Demonstrated Reserves)

North Dakota's coal resources fill the entire western portion of the state (see Figure 7). The coal bearing areas occupy 28,000 square miles or approximately 40% of the state. The estimated total resource is 351 billion tons.[1] Large portions of coal in North Dakota are considered removable by surface methods and, thus, represent large strippable reserves. Estimates have been made of 32 billion tons to a depth of 100 feet. This is based upon the total reserves inferred to be present.[1] The major coal deposits are those listed in Figure 7.

All coal in the major coal deposits is lignitic. Lignite is characterized by high moisture content and low heating value. Analyses of lignite throughout the major deposits,

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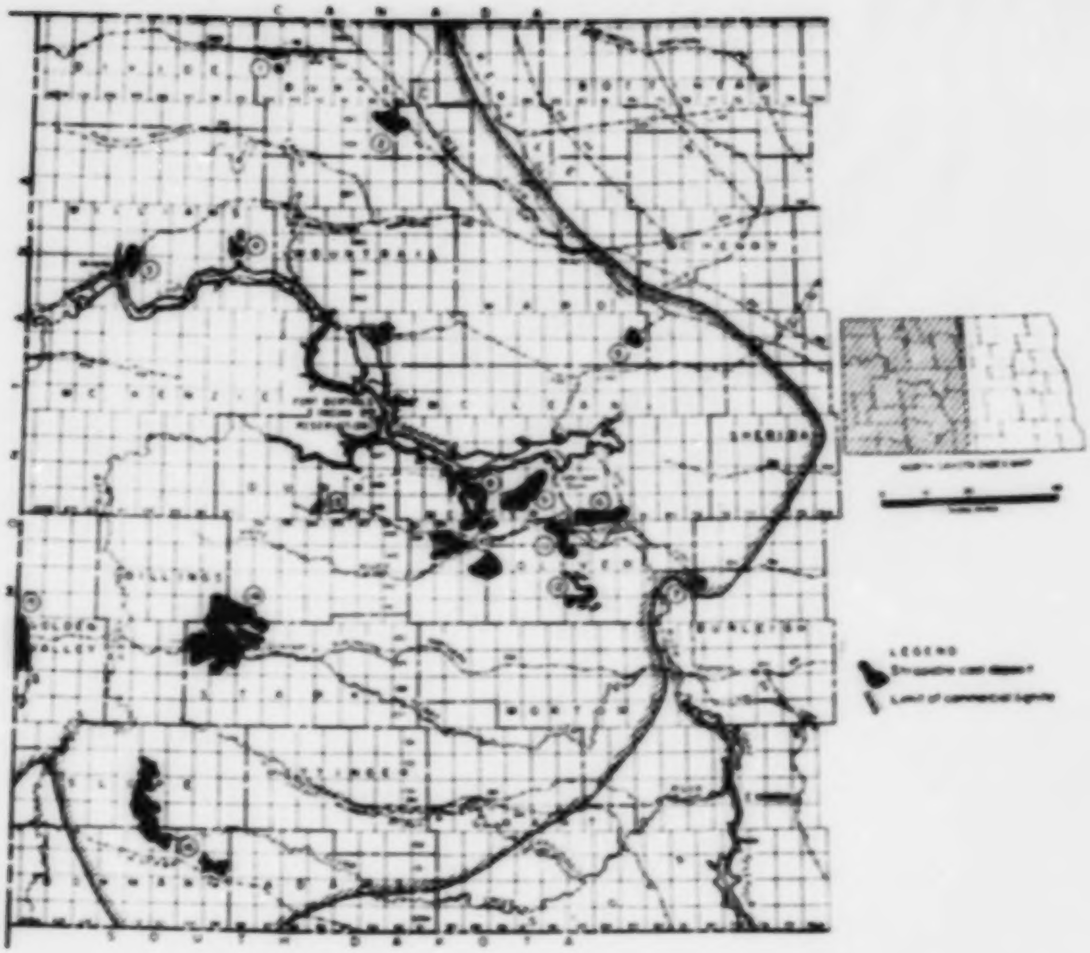
[1] pp. 504, 505, 511, 512.


CANADA
SOUTH DAKOTA
BURLEIGH
LEGEND
Strippable coal deposit
Limit of commercial lignite

COAL DEPOSITS

(1) Noonan-Kincaid
(2) Niobe
(3) Avoca
(4) M & M
(5) Velva
(6) Washburn
(7) Wilton
(8) Renner's Cave
(9) Hazen
(10) Beulah-Zap
(11) Stanton
(12) Center
(13) Dunn Center
(14) Dickinson
(15) Beach
(16) Bowman-Gascayne

Figure 7. Coalfields of North Dakota[7]

---

[7] Pollard, B. C., J. B. Smith, and C. C. Knox. Strippable Lignite Reserves of North Dakota - Location, Tonnage and Characteristics of Lignite and Overburden. Bureau of Mines Information Circular. 8537. 1972. p. 3.

however, show considerable variation in moisture, ash content, ash softening temperature, and heating value. (Refer to Table 26 for coal rank definition.)

The current trend has been to surface mine these coals because of the low market value and low Btu content. Seam thickness generally runs from 5 to 12 feet.

Oregon (1 MMT Demonstrated Reserves)

Sparse, widely distributed amounts of coal occur in Oregon. However, due to the severe power shortage in the Pacific Northwest, Oregon is included as an energy source to be examined. Resources of one billion tons are estimated to exist to depths of 6000 feet in the major coalfield, Coos Bay (see Figure 8).[8] Measured, indicated, and inferred estimates total nearly 66 million tons for a portion of the coal field to a depth less than 1500 feet.[9]

Coal in the Coos Bay field is subbituminous B, subbituminous C, or lignite. (Refer to Table 26 for coal rank definition.) Sulfur content is slightly higher than for other states considered in this report, 0.5 to 5.0% averaging less than 2.0%.

No coal is currently being mined in Oregon. Previous mining operations were underground and were abandoned due to the discovery of gas and oil in California. Small quantities of surface minable coal exist. Average coal seam thickness is approximately 5 feet.[9]

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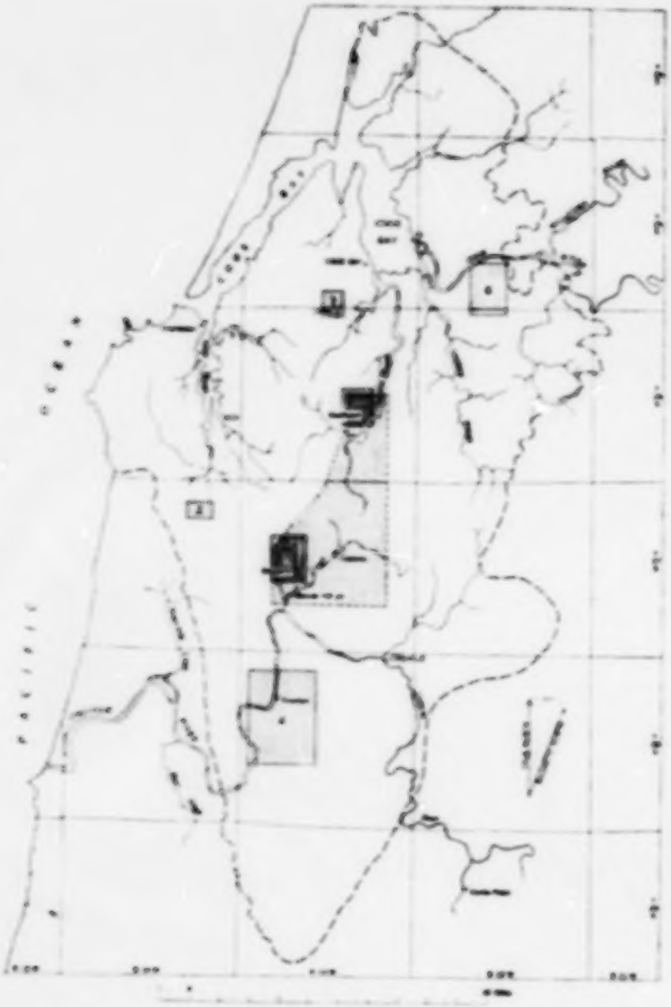
[8] Geer, M. R. Oregon. Coal Age. 78(5):149, April 1973.

[9] Mason, R. S., and M. I. Erwin. Coal Resources of Oregon. United States Geological Survey Circular. 362. 1955, pp. 3, 2.



COAL DEPOSITS

(1) Southport and Thomas
(2) South Slough
(3) Englewood
(4) Riverton
(5) Beaver Slough
(6) Lillian

▨ Area including reserves estimated by Allen and Baldwin, 1944

▩ Area including reserves estimated by Duncan, 1953

Figure 8. Coalfields of Oregon (Coos Bay region)[8]

---

[8] p. 150

South Dakota (428 MMT Demonstrated Reserves)

Lignitic coal occurrence in South Dakota is entirely in the northwestern portion of the state. Some 7000 to 8000 square miles of land are underlain by potentially coal bearing rock (see Figure 9). This area is an extension of the Montana and North Dakota lignite deposits. Estimates of strippable resources range from a half billion to more than one billion tons.[10] Firm estimates are sparse due to limited exploration.

Most coal in South Dakota is lignitic. A small amount of the coal is of a sub-bituminous grade but it is not commercially important. (Refer to Table 26 for coal rank definition.)

Future large-scale development is uncertain due to coal seams which are relatively thin and lenticular. If development is pursued, mining trends should follow the large-scale surface operations in North Dakota.

Utah (4,042 MMT Demonstrated Reserves)

Coal bearing rocks underlie over 3400 square miles of the state to depths of 3000 feet. Mapped and explored estimates indicate that some 32 billion tons of coal occur throughout the state to this depth. Utah's coal occurs in the 19 fields presented in Figure 10.[1] Over 99% of the mapped and explored coal is bituminous, with the balance subbituminous. (Refer to Table 26 for coal rank definition.) High quality coking coals are widespread and abundant in Utah.

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[10] p. 157.

[1] p. 536.

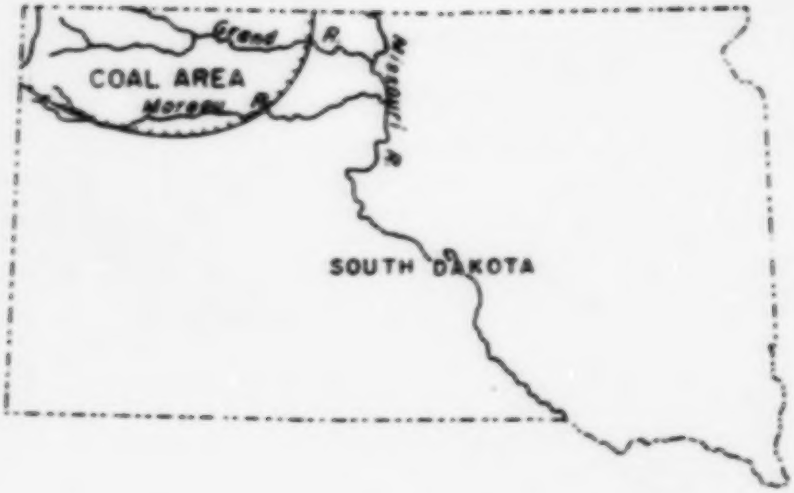
Grand R.
COAL AREA
Moreau R.
Missouri R.
SOUTH DAKOTA

Figure 9. Coal area of South Dakota[10]

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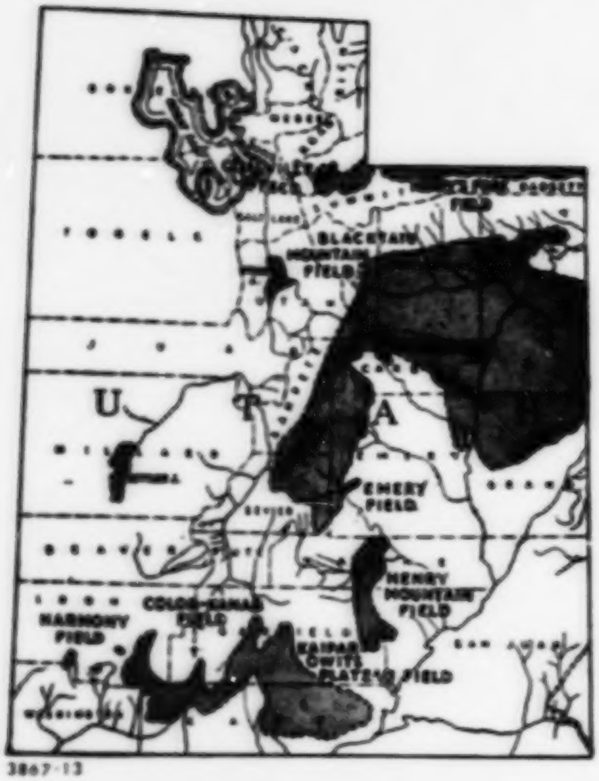
[10] Noble, E. A. South Dakota. Coal Age. 78(5):157, Mid April 1973.


U
T
A
TOOELE
BLACKTAIL MOUNTAIN FIELD
MILLARD
EMERY FIELD
BEAVER
IRON
HARMONY FIELD
COLOB-KANAB FIELD
HENRY MOUNTAIN FIELD
KAIPAROWITS PLATEAU FIELD
SAN JUAN
GRAND
WASHINGTON
3867-13

COAL FIELDS

(1) Alton
(2) Kaiparowits Plateau
(3) Kolob-Harmony
(4) Mount Pleasant
(5) Salina Canyon
(6) Sterling
(7) Wales
(8) Wasatch Plateau
(9) Book Cliffs
(10) Emery
(11) Vernal
(12) Henry Mountains
(13) Sego
(14) LaSal-San Juan
(15) Tabby Mountain
(16) Coalville
(17) Henry's Fork
(18) Goose Creek
(19) Lost Creek

Figure 10. Coalfields of Utah[1]

---

[1] p. 536.

Nearly all of the state's reserves are minable only by underground methods[1]. New areas are being explored which may preclude underground mining in favor of surface mining. Seam thickness can reach 10 feet or more. Nearly all current operations are in beds with thicknesses greater than 8 feet.[1]

Washington (1,954 MMT Demonstrated Reserves)

Coal occurs in scattered amounts throughout the state but is primarily concentrated along the western foothills of the Cascade Mountains. Estimated reserves of all ranks of coal to depths of 3000 feet by measured, indicated, and inferred categories are over six billion tons.[1] Twelve coal bearing areas in Washington State are identified in Figure 11.

Coal ranks from lignite to bituminous with the majority being subbituminous. (Refer to Table 26 for coal rank definition.) Severely contorted beds in the Whatcom County area contain the highest rank coal.

Several underground and surface mining operations are active in the Washington coal seams. The most notable of these is the Centralia coal mine which surface-mines coal in the Centralia-Chehalis Field ranges from 26 to 40 feet. Underground seams run considerably thinner.

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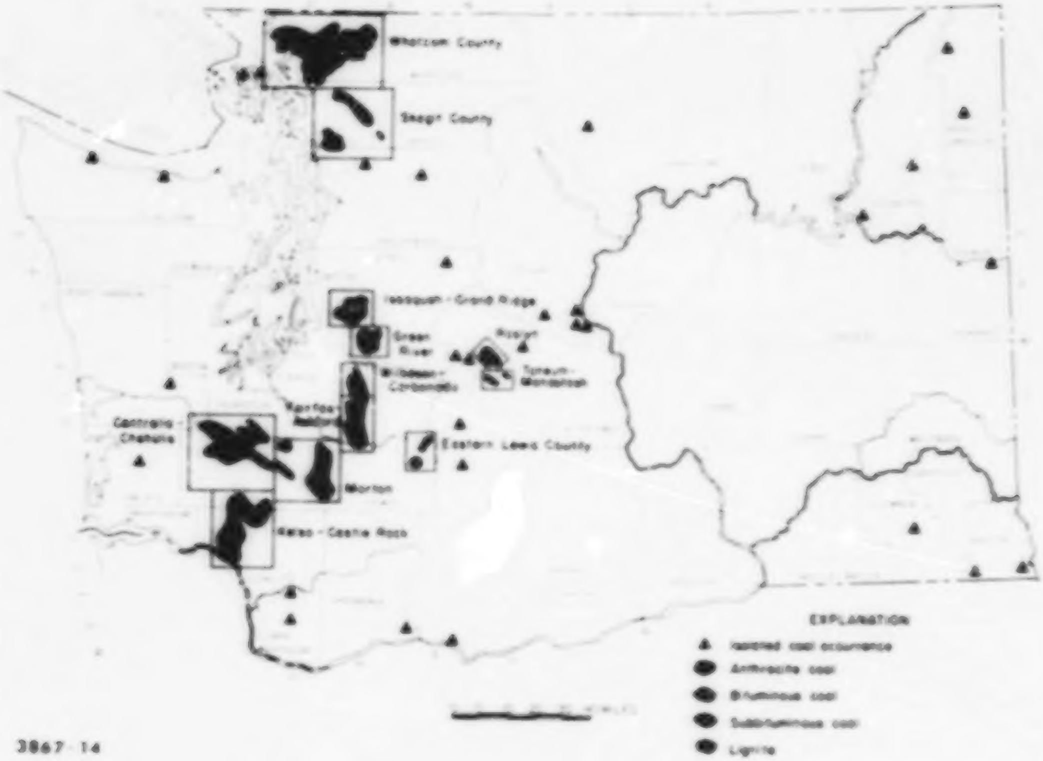
[1] pp. 536, 536, 545.


Whatcom County
Skagit County
Issaquah - Grand Ridge
Green River
Roslyn
Wilkeson-Carbonado
Taneum-Manastash
Fairfax-Ashford
Centralia-Chehalis
Eastern Lewis County
Morton
Kelso - Castle Rock
EXPLANATION
▲ Isolated coal occurrence
● Anthracite coal
● Bituminous coal
● Subbituminous coal
● Lignite
3867-14

Coal Areas

Whatcom County
Skagit County
Issaquah-Grand Ridge
Green River
Wilkeson-Carbonado
Fairfax-Ashford
Centralia-Chehalis
Morton
Eastern Lewis County
Kelso-Castle Rock
Roslyn
Taneum-Manastash

Figure 11. Coalfields of Washington[1]

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[1] p. 545.

Wyoming (51,228 MMT Demonstrated Reserves)

Coal bearing areas underly over 40,000 square miles or approximately 41% of the state. Over 136 billion tons of remaining coal resources to a depth of 3000 feet are thought to exist in a mapped and explored category.[11] Ten major regions--Powder River, Green River, Hams Fork, Hanna, Wind River, Bighorn, Rock Creek, Jackson Hole, Black Hills, and Goshen Hole--contain the 42 coalfields identified in Figure 12.

Coal ranks from lignite to high-volatile A bituminous. (Refer to Table 26 for coal rank definition.) Lignite is found only in the northeastern part of the Powder River Basin. Bituminous coal is restricted to the Black Hills Region and portions of the Hanna Field, Green River Region, Hams Fork Region and Bighorn Basin. High-volatile B and A bituminous coal is reported only in the Hams Fork Region.[1] Subbituminous coal is found in nearly all of the major regions.

Wyoming mining trends lean heavily toward surface mining although some underground operations are active. Coal seams can exceed 100 feet in thickness in some areas.

3.1.2 Principal Coalfield Resources

Table 6 gives a partial listing of the rank, age and formation of major coalfields in six of the ten states included in this study. The resources figures are derived from a

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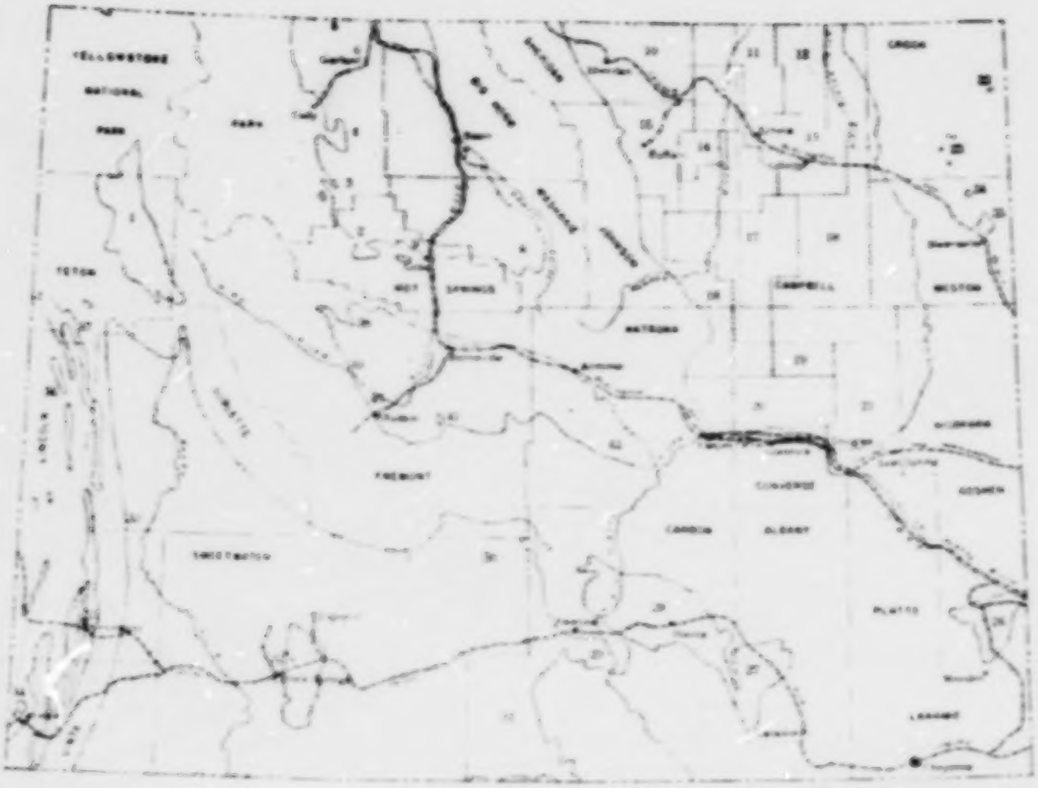
[11] Glass, G. B. Wyoming. Coal Age. 78(5):193, Mid-April 1973.

[1] p. 566.


YELLOWSTONE NATIONAL PARK
PARK
TETON
HOT SPRINGS
NATRONA
CAMPBELL
WESTON
CROOK
FREMONT
SUBLETTE
LINCOLN
CONVERSE
NIOBRARA
GOSHEN
CARBON
ALBANY
PLATTE
SWEETWATER
LARAMIE

FROM BERRYHILL, 1950

COAL FIELDS

(1) Jackson Hole
(2) Grass Creek
(3) Meeteetse
(4) Oregon Basin
(5) Silvertip
(6) Garland
(7) Basin
(8) Southeastern
(9) Be[illegible]
(10) Sheridan
(11) Spotted Horse
(12) Little Powder River
(13) Powder River
(14) Barber
(15) Buffalo
(16) Sussex
(17) Pumpkin Buttes
(18) Gillette
(19) Dry Cheyenne
(20) Glenrock
(21) Lost Spring
(22) Aladdin
(23) Sundance
(24) Skull Creek
(25) Cambria
(26) Goshen Hole
(27) Rock Creek
(28) Hanna
(29) Kindt Basin
(30) Great Divide Basin
(31) Little Snake River
(32) Rock Springs
(33) Labarge Ridge
(34) Evanston
(35) Kemmerer
(36) Greys River
(37) McDougal
(38) Muddy Creek
(39) Pilot Butte
(40) Hudson
(41) Alkali Butte
(42) Powder River

Figure 12. Coalfields of Wyoming[1]

---

[1] p. 565.

Table 6. PRINCIPAL COALFIELDS OF THE WESTERN STATES[3]

State	Field	County	Formation	Age	Rank	Estimated Reserves (million tons)
Arizona	Black Mesa	Navajo, Apache, Coconino	Dakota and Mesa Verde (Age)	Cretaceous	Sub-bituminous	[illegible]
Colorado	Denver Region	Weld, Morgan, Boulder, Adams, Arapahoe, Elbert, Douglas, El Paso	Laramie, Dawson Arkose	Cretaceous Paleocene	Sub-bituminous B & C to Lignite	[illegible]
	Raton Mesa	Huerfano, Las Animas	Vermejo, Raton	Cretaceous Paleocene	Bituminous High Volatile A-B	[illegible]
	North Park and Middle Park	Jackson, Grand	Coalmont	Paleocene	Sub-bituminous	[illegible]
	San Juan Region	Dolores, Montezuma, La Plata, Archuleta	Mesa Verde (Menefee, Fruitland) Dakota	Cretaceous	Bituminous	[illegible]
	Green River Region	Moffat, Routt	Mesa Verde (Iles, Williams Fork) Lance, Fort Union	Cretaceous Paleocene	High Volatile C to Sub-bituminous	[illegible]
	Uinta Region	Rio Blanco, Garfield, Mesa, Delta, Pitkin, Gunnison	Mesa Verde (Iles, Williams Fork)	Cretaceous	Anthracite to Sub-bituminous	[illegible]
Montana	Bull Mountain	Yellowstone, Musselshell	Fort Union	Paleocene	Sub-bituminous	[illegible]
	Bighorn Basin Great Falls	Carbon Cascade, Judith Basin	Fort Union Morrison	Paleocene Jurassic	Sub-bituminous High Volatile B	[illegible]
	Lewistown	Judith Basin, Fergus	Morrison	Jurassic	Bituminous	
	Bearpaw Mtns.	Hill, Liberty, Chouteau, Fergus, Blaine, Toole	Eagle SS, Judith River		Bituminous	[illegible]
	[illegible]	Glacier, Pondera, Teton	St. Mary River, Two Medicine		Bituminous	
	Electric	Park	Montana Group		High Volatile A	
	Livingston-Trail Creek	Park, Gallatin	Montana Group		High Volatile A	
	Lombard	Gallatin, Broadwater	Montana Group		High Volatile A	
	Lignite Area Sub bit. Area		Fort Union Fort Union	Paleocene Paleocene	Lignite Sub-bituminous	[illegible][a] (Total)
New Mexico	San Juan Basin	San Juan, McKinley	Mesa Verde (Fruitland, Menefee, Gibson)	Cretaceous	Sub-bituminous	[illegible]
Utah	Kaiparowits Kolob-Alton	Kane, Garfield Kane, Garfield, Iron, Washington	Straight Cliffs Dakota, Straight Cliffs	Cretaceous Cretaceous	High Volatile C Bituminous to Sub-bituminous	[illegible] [illegible]
	Wasatch Plateau	Sanpete, Sevier, Emery, Carbon	Mesa Verde (Blackhawk)	Cretaceous	High Volatile A-C	[illegible]
	Book Cliffs and Northern Wasatch	Carbon, Emery	Mesa Verde (Blackhawk)	Cretaceous	High Volatile A-C	[illegible]
Wyoming	Kemmerer	Lincoln, Uinta	Adaville, Frontier	Cretaceous	High Volatile A	[illegible]
	Rock Springs	Sweetwater	Mesa Verde (Rock Springs, Almond) Lance, Fort Union, Wasatch	Cretaceous Paleocene	Sub-bituminous to High Volatile C	[illegible]
	Hanna	Carbon	Mesa Verde, Medicine Bow, Ferris, Hanna	Cretaceous Paleocene	High Volatile C to Sub-bituminous	[illegible] (Total)
	Wind River Basin	Fremont, Natrona	Mesa Verde, Fort Union, Meeteetse	Cretaceous Paleocene		
	Bighorn Basin	Park, Hot Springs, Big Horn, Washakie	Mesa Verde, Meeteetse, Lance, Fort Union	Cretaceous Paleocene	High Volatile C to Bituminous	[illegible] (Total)
	Powder River Basin	Sheridan, Johnson, Natrona, Converse, Niobrara, Weston, Crook, Campbell	Lance, Fort Union, Wasatch	Cretaceous Paleocene Eocene	Sub-bituminous to Lignite	[illegible] (Total)

[a] [illegible] 5,312 million tons is covered by less than 120 feet of overburden and is [illegible]

---

[3] [illegible]

variety of sources and can only be taken at face value since it is unclear what basis was used to compute the tonnages. Additionally, the data do not reflect new field discoveries, new resource estimates, or coal production depletion. A more comprehensive listing of field resources is presented in Appendix A.

The coal reserve and resource data presented in Section 3.1 and in Appendix A were primarily extracted from open file government documents and related coal literature. The attempts to catalog accurate, reliable tonnage estimates of coal reserve data have resulted in many discrepancies between various authors. This is especially true for tonnage estimates for individual coalfields (Appendix A). The reasons for this problem are the highly proprietary nature of reserve estimates measured individually, and the lack of a consistent basis from coalfield to coalfield. The data are an indication of the present situation and represent the best information available through the open literature.

It is proposed that more exhaustive, reliable and useful estimates of coal reserves be made available on open file. This can be accomplished without violating proprietary deposit information by categorizing all coal deposit data in the "measured and indicated" category as defined by the Bureau of Mines. Since most proprietary coal reserve estimates are made by geological survey organizations, it would be their task to "non-proprietize" the data. More of the already existing information on specific "measured" reserves may then become available when combined with "indicated" reserve estimates.

3.2 MINING TECHNOLOGY

Coal mining in the West is mechanized to a high degree due to the severe shortage of skilled coal miners. Modern western coal mining operations are very large and efficient with high production per man per shift as seen in Table 7. Figures 13 and 14 show actual and projected output per man per day for the total U.S. to 1985. The 1969 Federal Coal Mine Health and Safety Act is seen to affect output but with a diminished effect after ten years.

Only large operators with definite market commitments can afford the capital cost and expenditures involved in equipping and operating an efficient western coal mine.[3] A description of individual coalfield characteristics such as seam thickness, topography and related items may be found in Appendix B. These characteristics dictate the method of mining and affect productivity.

3.2.1 Methods of Coal Mining

The following is a review of literature on the present status of coal mining methods in the western United States. Typical mining operations in the West use either underground or surface mining methods. Horizontal auger mining is less common but is gaining acceptance due to the large amounts of coal left in strip mine high walls. A description of each method of mining follows.

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[3] p. 10.

Table 7. AVERAGE PRODUCTION OF BITUMINOUS COAL AND LIGNITE IN THE WEST PER MAN SHIFT, 1960 and 1966[3]

State	Surface or Underground	1960 Tons		1966 Tons	
		Total	Prod/man-shift	Total	Prod/man-shift
Colorado	Underground	3,607,286	9.34	5,222,372	15.68
Montana	Surface	313,423	13.01	419,180	23.37
New Mexico	Surface	294,762	7.27	2,755,296	43.46
North Dakota	Surface	2,524,955	36.93	3,542,839	56.81
Utah	Underground	1,954,693	1[illegible].71	4,635,330	15.93
Wyoming	Surface	2,024,196	29.33	3,670,137	49.07
Total Tons		13,719,315	-	20,245,154	-
Average Production rate		-	17.90	-	32.93

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[3] p. 10.

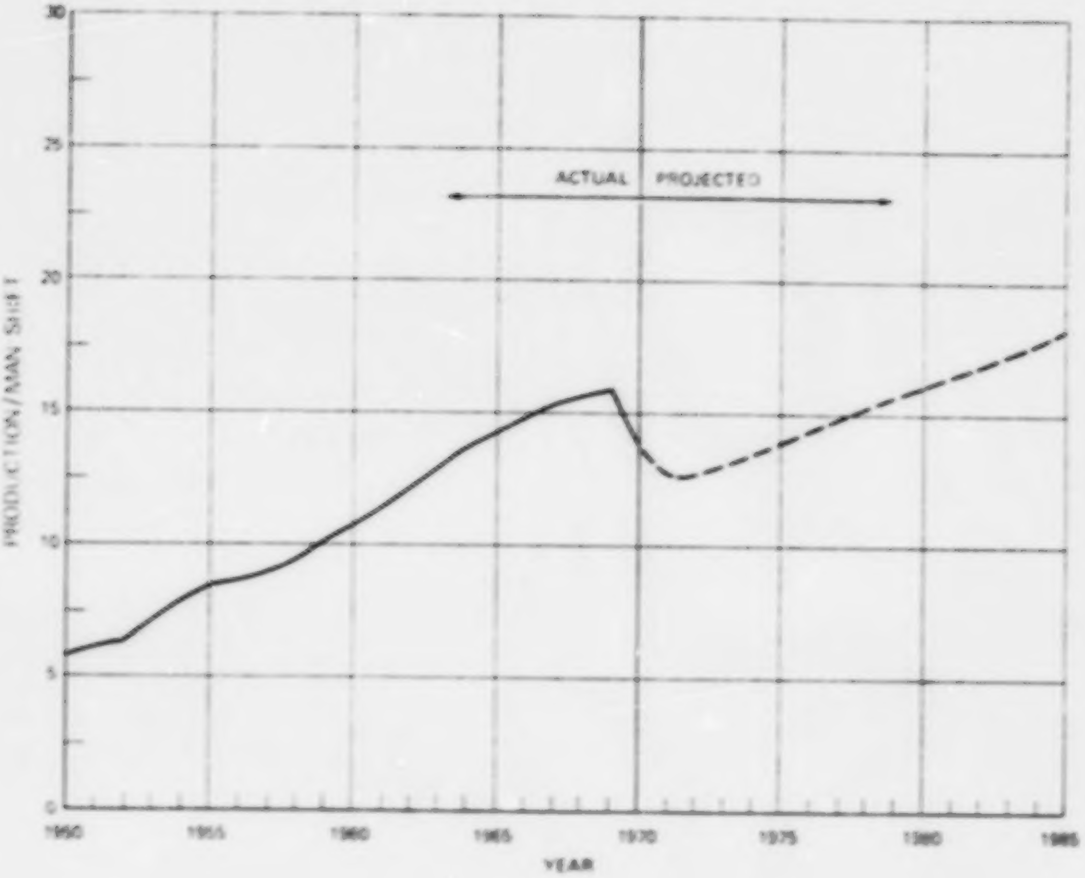

Figure 13. Output tonnage per man per shift at all underground bituminous coal mines[12]

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[12] Reichl, E. H. U.S. Energy Outlook - Coal Availability. Chairman Coal Task Group. National Petroleum Council. 1973. p. 36.

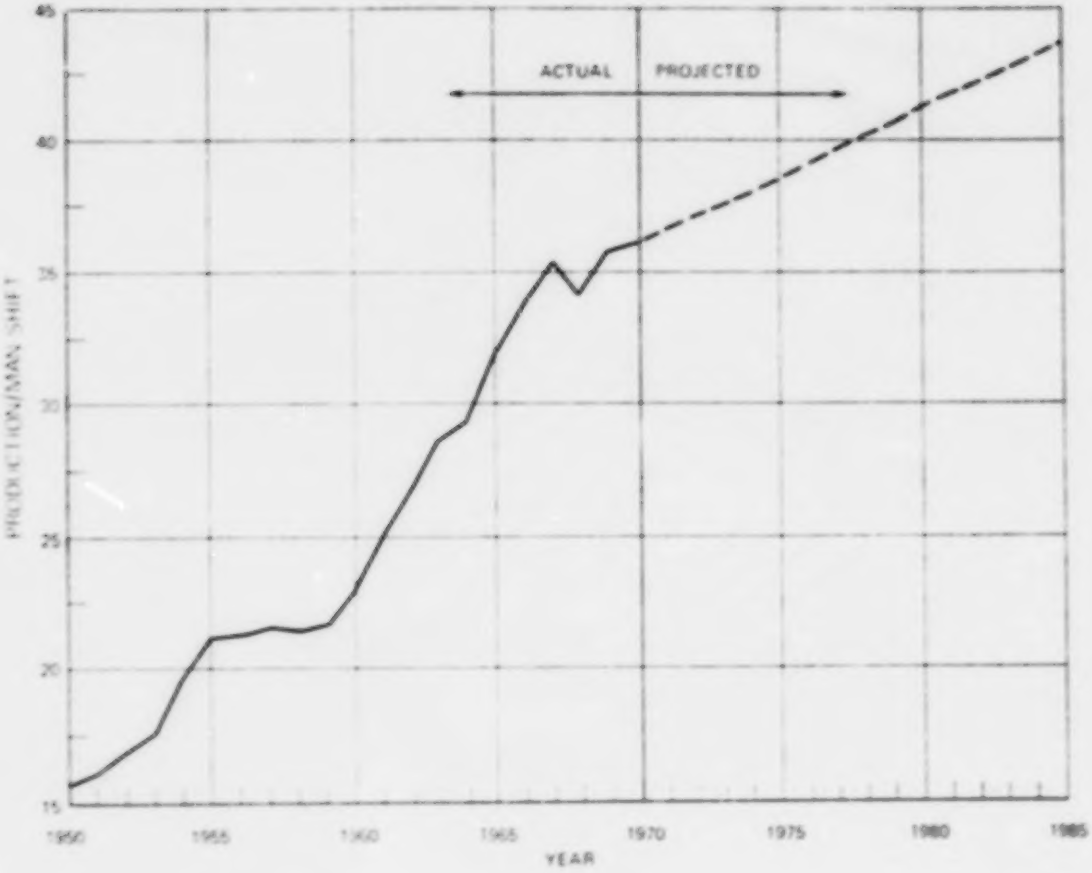

Figure 14. Output tonnage per man per shift at all surface bituminous coal mines[12]

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[12] p. 37.

3.2.1.1 Underground mining methods -

Underground or deep mining is used in the West to extract the higher quality bituminous coals such as those used in coke manufacturing. These bring a higher price than the lower quality, strippable subbituminous coals. Underground mining in the West is confined primarily to Colorado and Utah, the major sources of these types of coals.

Full-scale mechanization of underground mining due to improved technology has increased the output of these mines. However, mechanization has not decreased the complexity of the overall underground operation. All systems of western underground mining are executed in two distinct phases: the development phase and the production phase.[3] The development phase is used to gain access to the deep coal seam. Depending on geological and economic criteria, access may be by vertical shafts, inclined shafts, or slope and drift entries. Figure 15 shows these entry types. Panels of coal are exposed for mining by tunneling around the perimeter of a planned coal block. Other entries are established for ventilation in multiples of 2 to 7 depending on the design.[3]

The production phase is executed in one of two ways: the traditional room-and-pillar system or the newer longwall system which is becoming widely used. The typical room-and-pillar approach consists of rapidly moving the coal away from the working face in a series of operations. Undercutting

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[3] pp. 11, 11.

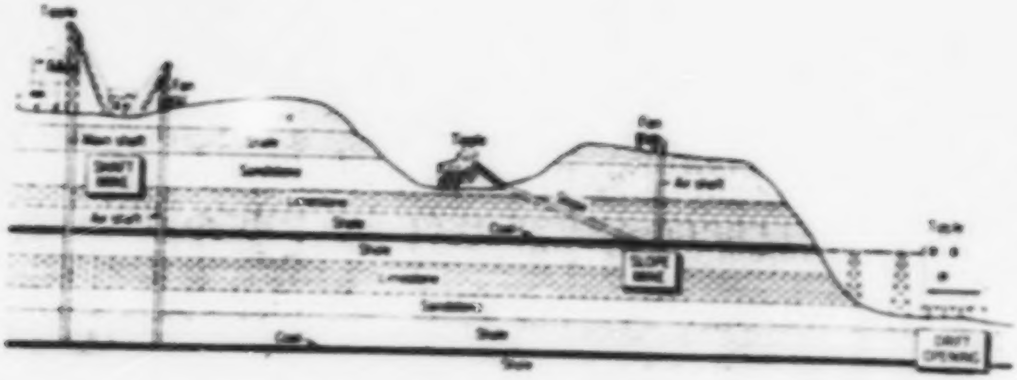
Tipple
Main shaft
SHAFT MINE
Sandstone
Limestone
Air shaft
Shale
Coal
Tipple
Fan
Air shaft
Slope
SLOPE MINE
Limestone
Sandstone
Shale
Coal
Tipple
DRIFT OPENING

Figure 15. Three types of entrances to underground mines--shaft, slope, and drift[13]

the coal panel, drilling and blasting, and loading are basic divisions of the operations. High capacity conveyors transport the load from the coal face to exterior haulage equipment. Figure 16 shows the basic operations of this conventional mining.

---

[13] Kent, J. A., Riegle's Handbook of Industrial Chemistry. 7th Edition. New York, Van Nostrand Reinhold Company, 1974. p. 31. Copyright 1974 by Litton Educational Publishing, Inc. Reprinted by courtesy of Van Nostrand Reinhold Company.

Adoption of novel ideas on room-and-pillar mining have recently eliminated coal face undercutting and blasting. The advent of the continuous mining machine which mechanically rips or bores out the coal and loads it in a single continuous operation has done much to increase the safety and productivity of underground mines.[3] Figure 17 depicts a continuous mining machine in operation. Both continuous mining and conventional mining may occur in the same coal mine. Figure 18 shows the layout of an idealized conventional underground mining cycle. This layout makes the most efficient use of the underground coal conveyors as seen by the staggered coal loading points in the cycle. A typical example of a mine utilizing this cycle is the Plateau Mine of the Plateau Mining Company.[1,14] The mine is located near Price, Utah, in Carbon County and produces steam coal from the 8-foot thick Hiawatha seam.

Longwall mining is a system where coal is taken out in a single continuous operation with the coal face advancing in an unbroken line or wall. No supporting pillars of coal are left after the operation since the roof is allowed to fall and settle behind the props as the mining advances.[3] The

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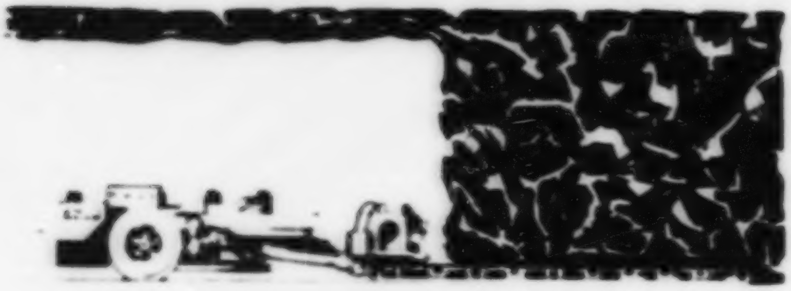
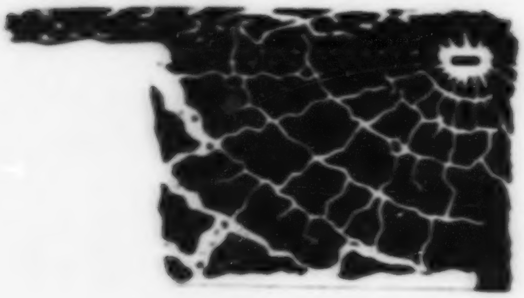
[3] pp. 12, 13.

[1] p. 724.

[14] Hileman, D. H., B. A. Collins, and S. R. Wilson. Coal Production From the Uinta Region, Colorado and Utah. Bureau of Mines Information Circular. 8497. 1970. p. 8.



UNDERCUTTING MACHINE



BLASTING

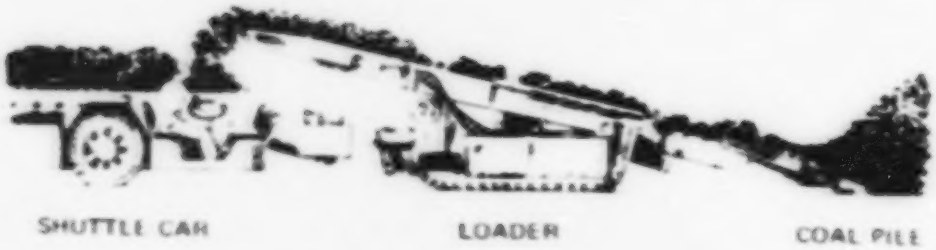

SHUTTLE CAR
LOADER
COAL PILE

Figure 16. Basic steps in conventional mining[13]

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[13] p. 31.

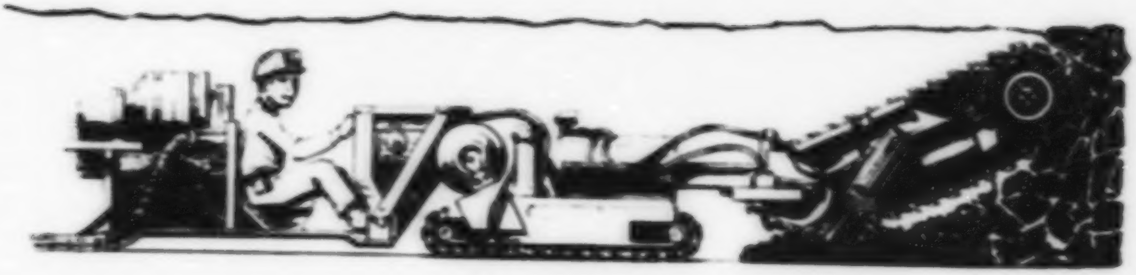

Figure 17. Continuous mining machine[13]

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[13] p. 32.

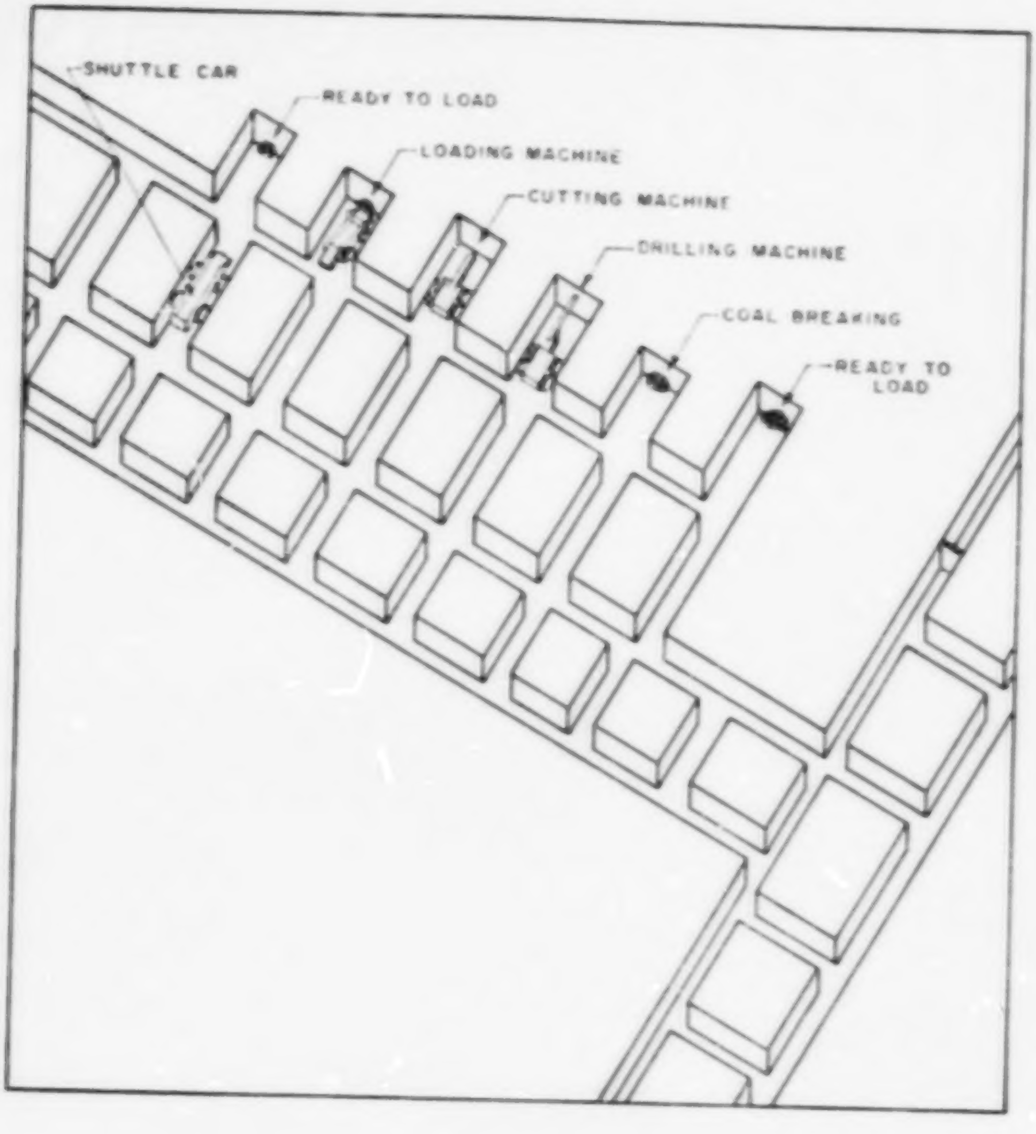
SHUTTLE CAR
READY TO LOAD
LOADING MACHINE
CUTTING MACHINE
DRILLING MACHINE
COAL BREAKING
READY TO LOAD

Figure 18. Idealized panel development showing method of working places in room-and-pillar conventional cycle[3]

longwall face may be over 300 feet in length depending on seam conditions. Figure 19 gives an overhead view of a typical longwall layout.

---

[3] p. 12.

The advancement of longwall mining in the United States was aided by the development of "yielding props" or roof supports. The supports yield slightly to the increasing roof pressure that results from mining into the coal face. The supports are usually actuated hydraulically, and they enable the roof to fall in a controlled manner after a specified width of coal face has been mined. They are also self-advancing which reduces labor and the hazards involved in setup.

Coal is sheared off the supported longwall face by a powerful drum shearer that directs the cut coal to a steel plow. The plow deflects the bulk of the material to conveyors. The coal shearing equipment traverses the length of the longwall face. After each pass the roof supports are automatically advanced and another mining cycle begins. Figure 20 shows a longwall mining machine operating on the coal face. Longwall mining finds application in underground mining areas that have poor top support and highly pitching seams, where room-and-pillar mining is difficult.[15] It is also being used as the sole mining method in some mines because of its higher productivity over room-and-pillar methods which leave support columns unmined. If properly operated, the longwall mine is quite safe due to the controlled collapse of mined out areas. Longwall mining is not applicable to discontinuous coal seams.

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[15] Jackson, D., Jr. Longwall Mining: Western Style. Coal Age. 76:72, April 1971.

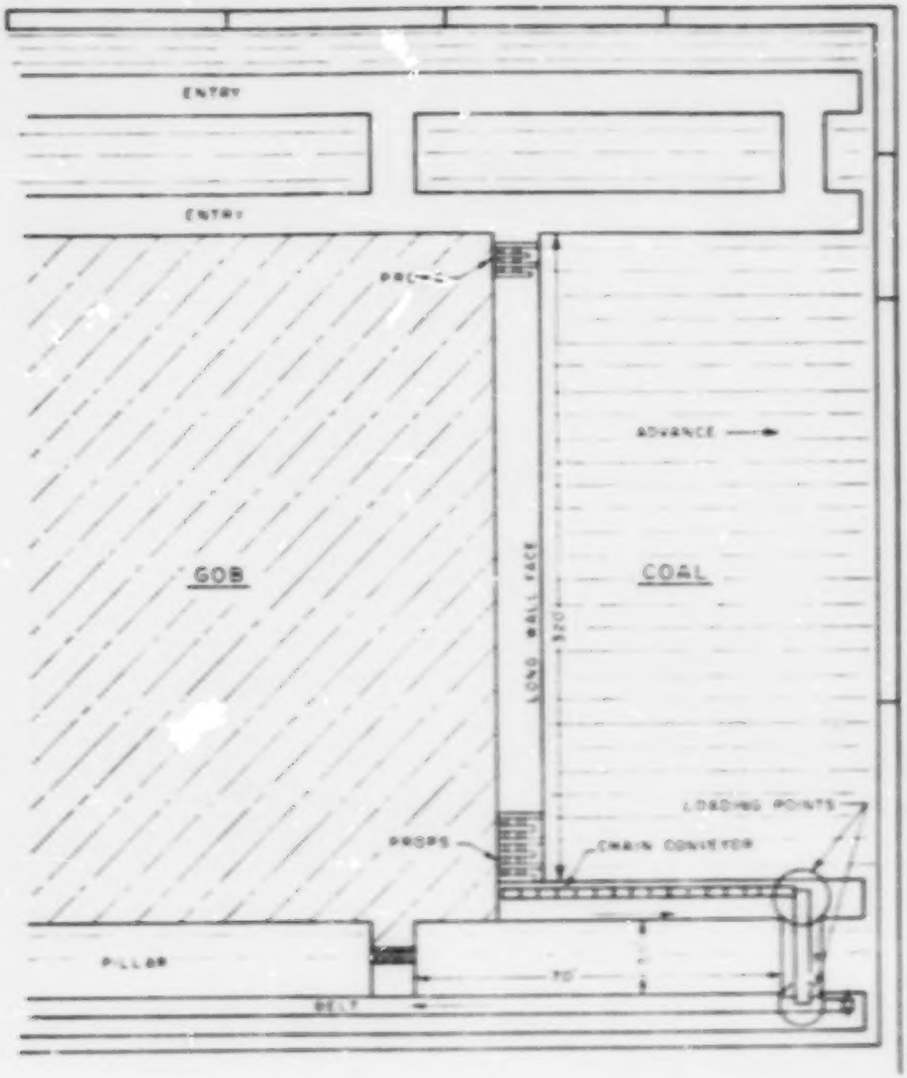
ENTRY
ENTRY
PROPS
ADVANCE
GOB
LONG WALL FACE
320'
COAL
LOADING POINTS
PROPS
CHAIN CONVEYOR
PILLAR
70'
BELT

Figure 19. Plan view of typical longwall layout[3]

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[3] p. 15.

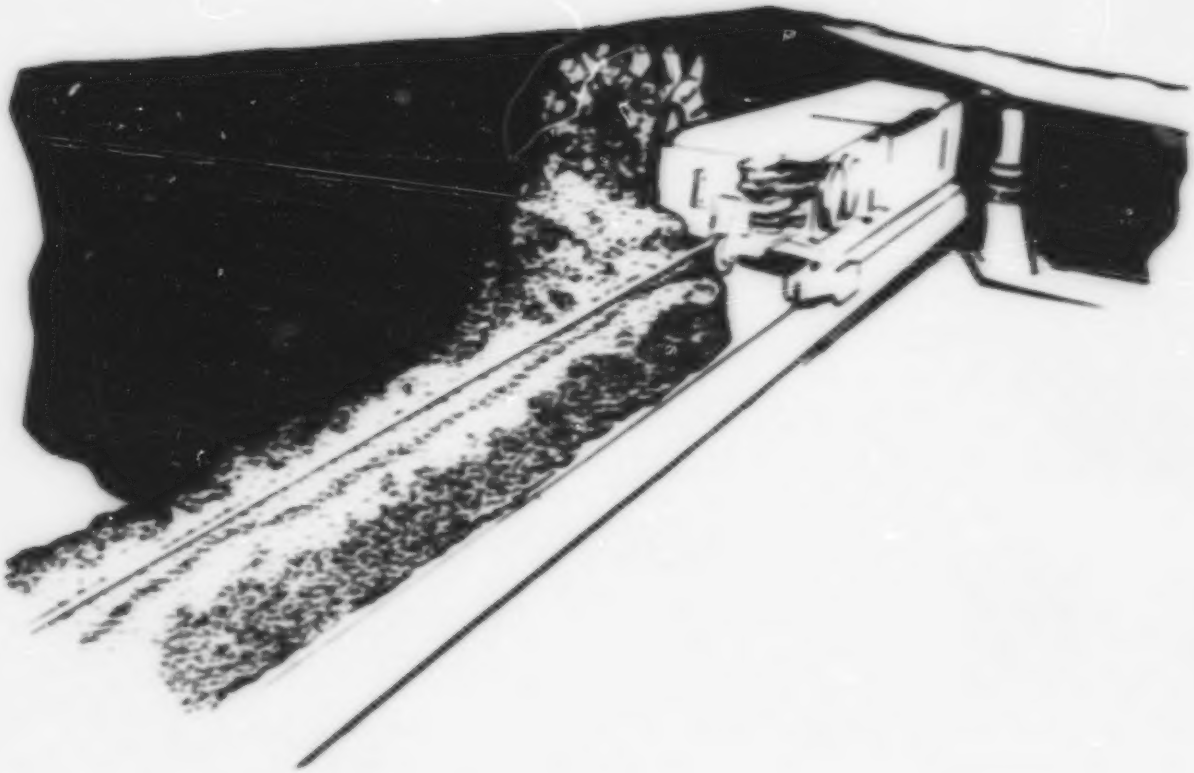

Figure 26. Longwall mining machine[13]

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[13] p. 19.

A typical example of longwall mining activity in the West is the Sunnyside No. 3 mine of the Kaiser Steel Corporation in Sunnyside, Utah.[15,16] The 54-inch thick Upper Sunnyside seam is producing coal of metallurgical coke grade. The Kaiser development in longwall mining, which was the first successful operation in the West (1961), came initially as a necessity. Room-and-pillar mining had previously been used in this mine but had to be stopped due to weak roof structure. Longwall mining allowed the time to stay open, provided for increased savings in roof materials, while ensuring positive roof control and improved overall productivity.

3.2.1.2 Strip mining methods

There are two basic methods of surface mining practiced in the United States: contour mining and area mining. Both types can be used only if the overburden thickness is less than approximately 200 feet. Draglines are prime movers of overburden and they are technically limited to this maximum excavating depth.[17]

Contour mining finds application in hilly terrain where topography governs pit design.[18] Though used in the East, this method is not widely practiced in the West because of the vast coal reserves located in its flat or gently rolling

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[15] p. 80.

[16] Woodruff, S. D. Methods of Working Coal and Metal Mines. Vol. 3. London, Pergamon Press. 1966. p. 239.

[17] Stefanko, R., R. V. Ramani, and M. R. Ferko. An Analysis of Strip Mining Methods and Equipment Selection. Office of Coal Research. Report No. 61. May 1973. p. 77.

[18] p. 29.

topography. It is also a more difficult and expensive operation than area mining. Usually the terrain is quite rough, and since the coal beds are nearly flat, only a few cuts can be made before the maximum economic stripping ratio is reached.[14] The stripping ratio is defined as the amount of overburden removed per ton of coal produced (cubic yards of overburden/ton coal).[16] This quantity increases as coal is stripped from a hillside coal region, and it soon becomes uneconomical to contour mine coal in that area due to the excessive amounts of overburden to be removed. In light of the foregoing, contour mining will probably not be considered as a viable means of mining western coal.

Area mining is the major strip mining method used on western coal lands. Simply stated, area mining involves the development of large flat open pits in a series of long narrow strips (usually 100 feet wide by a mile or more in length).[14] The objective is to expose, recover, and haul away the coal in as economical a fashion as possible, which usually means that the overburden should be moved only once.

Figure 21 shows two views of a developed strip mine typical of those found in eastern Montana. In this case a dragline initiates the mining cycle by opening a 100-foot wide pit to expose the 25-foot thick Rosebud coal seam for a length of one mile.[17] Overburden is of an incompetent nature and blasting is not required to remove it. The coal is drilled and the boreholes loaded with an ammonium nitrate-fuel oil

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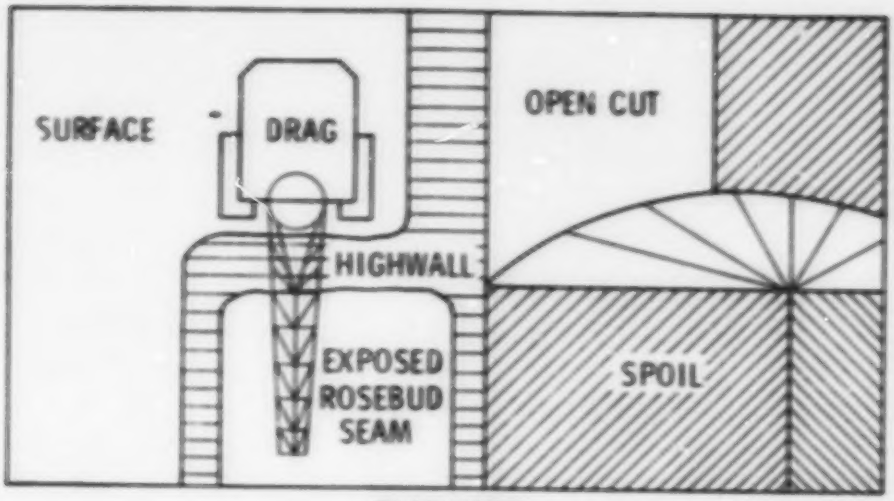
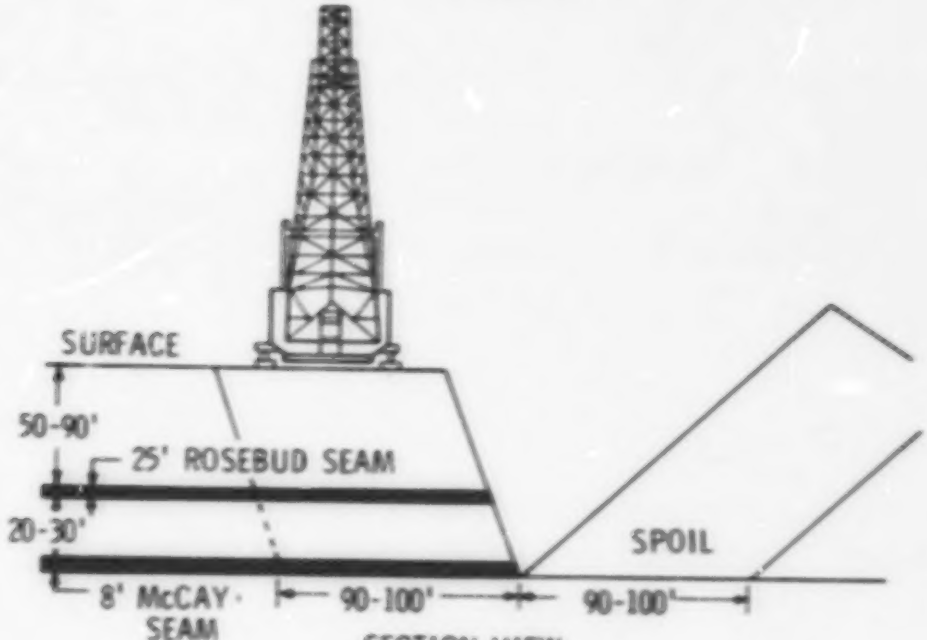
[14] pp. 30, 30.

[16] p. 394.

[17] p. 49.


SURFACE
DRAG
OPEN CUT
HIGHWALL
EXPOSED
ROSEBUD
SEAM
SPOIL

PLAN VIEW


SURFACE
50-90'
25' ROSEBUD SEAM
20-30'
8' McCAY
SEAM
90-100'
90-100'
SPOIL

SECTION VIEW

Figure 21. Initial pit dimensions for dragline exposing the Upper Rosebud Coal Seam[17]

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[17] p. 50.

(ANFO) mixture for blasting. Following blasting, a loading shovel removes the entire pit width by loading into several 100-ton haulage trucks which take the coal to the crusher. Two bulldozers begin leveling the spoil. Since two coal seams are present, the dragline again comes into play, removing the partings to expose the 8-foot thick McCay seam. The new seam is worked in the same manner, and the dragline moves into position to open the next pit. All overburden from each successive pit is placed into spoil banks located in the previously mined out pit.

The cycle is then repeated to the limit of the mine boundaries. Bulldozers level the spoil to a rolling contour in anticipation of new legislation for strip mine reclamation. The planting of trees and grasses chosen for their ability to survive the semi-arid conditions is the final step and is considered a vital part of the strip mine planning.

Area strip mining is largely equipment intensive and frequently the equipment selection guidelines are derived solely from past experience. The variety of excavating and haulage equipment is vast. The major parameters that influence equipment selection are coal production rate, type and depth of overburden encountered, spoil pile height, thickness of coal deposit, maintenance, and weather conditions.[17] However, in practice equipment is usually selected for range and production capabilities and then the pit is designed to suit the selected equipment.[17]

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[17] pp. 85-105, 85-105.

Two kinds of excavating equipment not mentioned previously are scrapers and bucket-wheel excavators. Scrapers can be used instead of high cost draglines for removing overburden if the overburden is fairly soft and easily broken. Scrapers are also useful when the coal seam dips at such an angle that it would not be economical to strip with a dragline.[18] Bucket-wheel excavators are expensive, high production rate machines that may be selected when dragline capacity is inadequate. Their maintenance usually is considerably costlier than that required for draglines. Bucket-wheel excavators are frequently used in tandem operation with draglines. Another item of coal handling equipment recently receiving much attention in the West is the highly mobile rubber-tired front-end loader. Table 8 summarizes the characteristics of strip mining equipment, and Table 9 gives typical capacities of the equipment.

3.2.1.3 Auger mining methods

Coal augering is normally used to mine the high walls left by strip mining operations. This mining system bores horizontal perpendicular holes in the coal face and extracts the coal by means of a screw attached to the auger bit.[16] Conveyors handle the coal thus produced. Figure 22 shows a dual-bit coal auger in operation. Augering of coal can add significantly to the amount of recoverable coal reserve

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[18] Haley, W. A., J. D. Dutton, and J. P. Tuffey. An Economic Evaluation of Wheel Tractor Scrapers. Coal Age. 77:97, June 1972.

[16] pp. 438-442.

Table 8. CHARACTERISTICS OF EXCAVATING AND HAULAGE EQUIPMENT[3]

EXCAVATORS

SHOVELS

1. Can give high production.
2. Can handle all types of material including large blocky material.
3. Are limited to fairly rigid operating conditions.
4. Require supporting equipment for waste disposal except in some strip mining.

DRAGLINES

1. Have the ability to dig well above and below grade.
2. Can function under less rigid operating conditions than shovels.
3. Are only 75 to 80% as efficient in production as a shovel of comparable size due to less precise motions.
4. May or may not require supporting waste haulage equipment.
5. Are normally used for handling unconsolidated and softer materials, but larger units can handle blasted rock.

SCRAPERS

1. Have excellent mobility.
2. Are limited to fairly soft and easily broken material for good production, although they can handle broken material up to about 21 in. in size.
3. Usually require pushers to assist in loading.
4. Usually are operated without supporting disposal equipment where the distance to the dump area does not exceed one mile.

BUCKET-WHEEL EXCAVATORS

1. Must be operated under very rigidly engineered conditions.
2. Have very high capital cost.
3. Are limited to fairly easy digging.
4. Are capable of high production rates.
5. Require auxiliary disposal systems.

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[3] p 17.

Table 8 (continued). CHARACTERISTICS OF EXCAVATING AND HAULAGE EQUIPMENT[3]

HAULAGE EQUIPMENT

BULLDOZERS

1. Are commonly limited to a fairly short operating radius of about 500 feet.

SCRAPERS

1. Require good roads to minimize tire costs.
2. Are fast but are limited economically to an operating radius of approximately one mile.

TRUCKS

1. Require good roads to minimize tire costs.
2. Can negotiate steep ramps.
3. Are usually limited by economics to an operating radius of about 2-1/2 miles.
4. Are very mobile.

TRAINS

1. Are high-volume, long-distance, low-unit-cost carriers.
2. Require tracks that closely conform to engineering specifications.
3. Have a high initial capital cost.
4. Cannot handle adverse grades much greater than 3%.
5. Can handle coarse, blocky material.

CONVEYORS

1. Are high-volume, long-distance, low-unit-cost carriers.
2. Are difficult and costly to move.
3. Have a high initial capital cost.
4. Can handle steep adverse grades (up to about 40%).
5. Require material broken into fairly small pieces for good belt life.

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[3] p. 17.

Table 9. TYPICAL CAPACITIES OF WESTERN STRIP MINING EQUIPMENT IN 1973[19]

	Draglines, cubic yards	Shovels, cubic yards	Haulage Units, tons
Arizona	14-36	16	120
Montana	30-70	16	100-120
New Mexico	10-50	15-24	50-120
North Dakota	28-32	?	40-120
Wyoming	17-62	15-24	50-120

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[19] Glass, G. B. Recent Surface Mining Development in the Western States. Geological Survey of Wyoming at Laramie, (Paper presented at 1974 Coal Convention, American Mining Congress held in Pittsburgh, Pennsylvania, May 7, 1974,) p. 4.

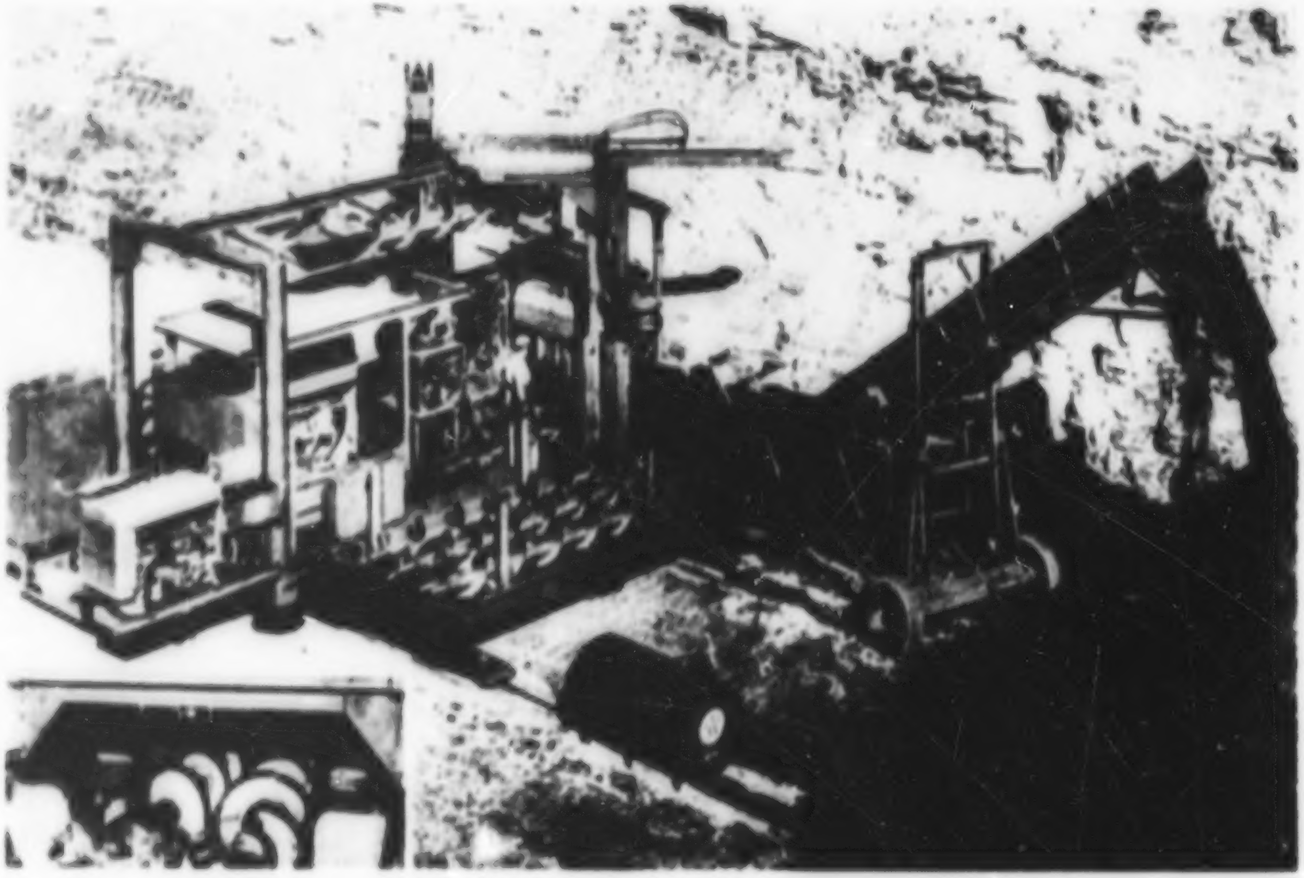

Figure 22. Dual coal auger[16]

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[16] p. 439.

in a strip mine. A single-bit augering machine was used to follow up surface mining near Reliance, Wyoming, in 1971 and 1972.[20] Augering was discontinued in 1972 because the mine closed. The auger-mined seams ranged between 4 and 10 feet thick. The augering operation was a success since 12,000 tons of otherwise unrecoverable coal were mined in a few months. Augering operations are not widely used in the West, but it is probable that combined strip mining/auger mining trends will evolve due to both attractive economics and legislation limiting extensive strip mining.

3.2.2 Methods of Coal Preparation

The washing of coal refers to the process of removing impurities prior to coal utilization as a fuel. Current state-of-the-art washing removes some part of coal ash and total coal sulfur. The objective of washing steam coal is to increase the coal's dollar market value by upgrading the calorific value (ash removal) and/or to lower the pollution hazard (sulfur removal). Coking coal is often washed to meet rigid sulfur and ash level restrictions, which, if exceeded, affect the quality of steel or other metal products. Current wash practices are limited to physical separation of the impurities from coal. Methods of washing are divided into four categories as they apply to coarse and fine concentration of coal. These are as follows:[21]

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[20] Glass, G. B. Summary of Coal Mining in Wyoming. Wyoming Geological Association. (Presented at 25th Field Conference, Laramie, Wyoming, 1973.) p. 124.

[21] Leonard, J., and D. R. Mitchell. Coal Preparation. New York. American Institute of Mining, Metallurgical and Petroleum Engineers, Inc. 3rd Edition. Seeley W. Mudd Series, 1968. pp. 9-11, 11-20.

Category	Coal Size Washed
Dense Medium Separation	Coarse, Fine
Hydraulic Separation	Coarse, Fine
Froth Flotation	Fine
Dry (Air) Concentration	Fine

3.2.2.1 Ash removal

Underground mined coals are often washed because continuous mining machines and other coal recovery equipment cannot distinguish rock partings and impurities from coal. This is true especially for thin seams. Washing results in some loss of coal yield tonnage in the refuse fraction. Certain strip and auger mined coals must be washed to remove rock and bony partings from thin, badly faulted, or multiple seams. Table 10 gives the amounts of Western coal cleaned in 1972. An estimated grand total of over 10 million tons of coal is cleaned annually. This amounted to 21% of the total 1972 production.

Although coal cleaning is not extensively practiced in the West, it is used locally to clean coking coals and particularly dirty steam coals. This can upgrade the calorific value in many instances. In Table 10 it is fairly safe to assume that the underground coal cleaned was used for coke and the strip coal was used for steam. Economics generally dictate that Western steam coal be used "as is" because any increase in Btu content per pound would be unable to offset the large transportation costs to midwest markets.

Table 10. WESTERN COAL CLEANED MECHANICALLY IN 1972[22]
(Thousand Short Tons)

State	Underground Mines		Strip Mines		Auger Mines		Total, All Mines	
	Total Production	Cleaned	Total Production	Cleaned	Total Production	Cleaned	Total Production	Cleaned
Colorado	3070	1240	2452	-	-	-	5522	1240
Utah	4770	3333	32	-	-	-	4802	3333
Washington	29	29	2606	2597	-	-	2635	2626
Arizona								
Montana								
New Mexico	1472	713[a]	35510	2395[a]	-	-	36982	3108[a]
North Dakota								
Wyoming								
Total Western States	9341	5315	40600	4992[a]	-	-	49941	10307[a]

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[a] Estimated

[22] Anon. Minerals Yearbook 1972. Volume I. Metals, Minerals, and Fuels. Bureau of Mines, 1974. pp. 344-346, 373.

3.2.2.2 Sulfur removal -

The three forms of sulfur which constitute total coal sulfur content are pyritic (FeS_2), sulfate ($SO_4^=$), and organic (RSH, RSR, RSSR, and thiophenic).[21] Only the pyritic form of sulfur can be removed from coal by current physical separation methods. The sulfate and organic forms are termed "bound" because they are removable only by methods which can penetrate the coal matrix. Chemical leaching and solvent refining are two examples of experimental methods which can remove organic sulfur.

The predominant form of sulfur in western coals is organic form. Inherently low sulfur content precludes the need for further sulfur removal in most of these coals. The assumption that all western coals are inherently low in sulfur is fallacious in that point-to-point variations can exist. Some western coals, mainly in parts of Montana and North Dakota, do not meet 1971 EPA standards of 0.6 lb sulfur per million Btu (see Section 5). There is a great need for a reliable large scale process to remove organic sulfur from coal.

3.3 COAL PRODUCTION/CONSUMPTION AND PRICES F.O.B. MINE

A total of about 109 western coal mines produced nearly 58 million tons of bituminous, subbituminous and lignite coal in 1973. Forty-nine of these 109 mines produced over 100,000 tons per year. Table 11 gives a state-by-state

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[21] pp. 1-44 and 1-45.

Table 11. TOTAL STATE COAL PRODUCTION, 1973[22,23]
(thousand short tons)

State	Strip	Number of[a] Mines	Deep	Number of[c] Mines	Production Total
Arizona	2965	1	0	0	2965
Colorado	2855	8	3377	27	6232
Montana	9930	6	20	3	9950
New Mexico	8278	4	1062	1	9340
North Dakota[b]	7400	14	0	0	7400
Oregon	0	0	0	0	0
South Dakota	0	0	0	0	0
Utah	35	1	5105	21	5140
Washington	3175	2	35	1	3210
Wyoming	12920	13	680	5	13600
Totals	47558	49	10279	58	57837
% Total Western Coal	82.2	46	17.8	54	100.0
% Total U.S.	17.3	2.1	3.4	2.9	10.0

[a] Includes coking coal production

[b] Lignite

[c] 1972 data

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[22] pp. 345, 346.

[23] Nielsen, G. F. 1974 Keystone Coal Industry Manual. New York, McGraw-Hill, Inc. 1974. p. 446.

breakdown of surface and underground production by method of mining for 1973. It is seen that 82% of the western product came from surface mines, even though there are fewer surface mines than deep mines. Nearly 58 million tons produced in the West represent 10% of the 1973 U.S. total. Wyoming leads in production totals by a substantial margin with 23% of the total western production. A listing of production by major mines for 1972 and 1973 may be found in Appendix C.

Production is expected to increase rapidly in the immediate future. Although stringent strip mining legislation threatens to shut down all western surface mining activities, it is not expected to take effect for several years (see Section 3.4.3). Production estimates and projections for the next several years for five major surface mining states are shown in Table 12.

Increased production of western low-sulfur coal depends largely on the ability of mining administrators to obtain long-term contracts with the industry. The high capital cost involved in mining operations must be justified by long term production and economies of scale.

Table 13 shows a forecast by Mineral Industry Surveys for 1980-1981 western coal annual production. This projection is for mines on Federally owned lands (35% of western coal areas). A western production of 85 million tons is forecast for use by major contract holders as far away as Louisiana and Illinois. Much of this tonnage, the majority of which is low sulfur coal, however, can be affected by legislation pertaining to coal production on Federal lands. Some discussion of western coal mining legislation is presented in Section 3.4.3.

Table 12. ANNUAL COAL PRODUCTION (1969–1972) WITH ESTIMATES FOR 1973, 1975, 1980, and 1985[19]

State	Production in Millions of Tons							
	1969	1970	1971	1972	1973	1975	1980	1985
Arizona[a]	.0	0.1	1.1	1.1	2.9	10.0	13.0	13.0+
Montana[b]	1.0	3.4	7.1	8.2	9.9	19.8	41.0	74.0
New Mexico[c]	4.5	7.4	8.1	8.2	9.3	17.0	27.0	27.0+
North Dakota[b]	4.7	5.6	6.1	6.8	7.4	11.7	19.0	49.1
Wyoming[d]	4.6	7.2	8.1	10.9	13.6	22.9	87.0	140.0
Totals	14.8	23.7	30.5	35.2	43.1	81.4	187.0	303.0

[a] Forecast by Arizona Bureau of Mines, 1973

[b] Forecast by Northern Great Plains Resource Program (most probable), 1973

[c] Forecast by New Mexico State Bureau of Mines and Mineral Resources, 1973

[d] Forecast by Wyoming Geological Survey, March 1974

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[19] p. 1.

Table 13. PROJECTED COAL PRODUCTION FROM FEDERAL SURFACE COAL MINES FOR STEAM ELECTRIC PLANT FUELS FOR 1980-1981[2*]

State	Location of Mine	Major Contracts Annual Tons	Location of Powerplant
Colorado	Bear Creek	800,000	Denver, Colorado
	Hayden	1,000,000	Hayden, Colorado
	Craig	650,000	Craig, Colorado
	Sub-total	[illegible]	
Montana	Colstrip	150,000	Billings, Montana
	Colstrip	800,000	Minneapolis, Minnesota
	Colstrip	2,400,000	Chicago, Illinois
	Colstrip	920,000	Wisconsin
	Colstrip	1,200,000	St. Paul, Minnesota
	Colstrip	1,200,000	Colstrip, Montana
	Colstrip	1,500,000	Cohasset, Minnesota
	Colstrip	2,300,000	Becker, Minnesota
	Savage	90,000	Sidney, Montana
	Decker	4,500,000	Chicago, Illinois
	Decker	8,500,000	St. Clair, Michigan
	Decker	5,000,000	American Electric Power (Locations Unknown)
	Sub-total	[illegible]	
North Dakota	Beulah	750,000	Hoot Lake, Minnesota
	Beulah	250,000	Beulah, Mandan, N.D.
	Gascoyne	250,000	Ortonville, South Dakota
	Stanton	1,000,000	Stanton, North Dakota
	Center	400,000	Center, North Dakota
	Zap	100,000	Stanton, North Dakota
	Sub-total	[illegible]	
New Mexico	Fruitland	3,400,000	Fruitland, New Mexico
	Gallup	250,000	Joseph City, New Mexico
	Sub-total	[illegible]	
Utah	Alton	5,400,000	Las Vegas, Nevada St. George, Utah
	Sub-total	[illegible]	
Wyoming	Glen Rock	1,500,000	Glen Rock, Wyoming
	Hanna	100,000	Denver, Colorado
	Hanna	1,300,000	Sioux City, Iowa
	Hanna	1,200,000	Council Bluffs, Iowa
	Hanna	4,500,000	Nebraska
	Point Rocks	3,000,000	Point of Rocks, Wyoming
	Kemmerer	250,000	Kemmerer, Wyoming
	Gillette	520,000	Rapid City, South Dakota
	Gillette	1,400,000	Gillette, Wyoming
	Gillette	2,400,000	Pueblo, Colorado
	Gillette	3,500,000	Avinger, Texas
	Gillette	6,400,000	Topeka, Kansas
	Gillette	3,700,000	Muskogee, Oklahoma
	Gillette	1,800,000	Western Nebraska
	Gillette	1,000,000	Amarillo, Texas
	Gillette	1,700,000	Louisiana
	Gillette	2,000,000	Redfield, Arkansas
	Sub-total	[illegible]	
Grand Total		86,420,000	

[2*] Anon. Assessment of the Impact of Air Quality Requirements on Coal in 1975, 1977, 1980. Bureau of Mines Mineral Industry Surveys, Division of Fossil Fuels, Mineral Supply. January 1974. pp. 178-179.

The distribution and utilization of western coal are important from the standpoint of out-of-state marketability. Table 14 gives the definition of western producing districts as outlined by the U.S. Bureau of Mines. These districts are shown in Figure 23. Table 15 shows points of destination from these western coal producing districts along with associated tonnage. It is seen that the ultimate destinations of western coal are primarily in-state and midwestern, with one exception shipped to New York. Most western coal (70%) stays in the western regions. Additional information on utilization by individual user type is found in Appendix D.

An interesting aside is the change in total production in just one year's time. Roughly 50 million tons were produced in 1972 while 58 million tons were produced in 1973.[23]

Colorado and Utah produce the majority of coking coals in the West. Table 16 shows 1972 annual production figures for the states having the most high quality coking coal potential. All of this coal was mined underground. The 1972 data in Table 16 indicate that coking coal production tonnage is minor in comparison with steam coal production. Over 90% of the coal produced in the West was used for steam production in 1972.

A list of the latest actual average yearly surface and underground coal prices (f.o.b. mine) is given in Table 17. Underground coal costs considerably more than surface coal because of higher costs of mining and usually superior coking and

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[23] p. 446.

Table 14. DEFINITION OF WESTERN BITUMINOUS COAL AND LIGNITE PRODUCING DISTRICTS[25]

DISTRICT 16. - NORTHERN COLORADO
All mines in the following counties in the State:
Adams
Arapahoe
Boulder
Douglas
Elbert
El Paso
Jackson
Jefferson
Larimer
Weld

DISTRICT 17. - SOUTHERN COLORADO
Colorado - All mines except those included in District 16.
New Mexico - All mines except those included in District 18.

DISTRICT 18 - NEW MEXICO
New Mexico - All mines in the following counties:
Grant
Lincoln
McKinley
Rio Arriba
Sandoval
San Juan
San Miguel
Santa Fe
Socorro

Arizona - All mines in the State
California - All mines in the State

DISTRICT 19 - WYOMING
Wyoming - All mines in the State
Idaho - All mines in the State

DISTRICT 20 - UTAH - All mines in the State

DISTRICT 21 - NORTH DAKOTA-SOUTH DAKOTA
All mines in North Dakota and South Dakota

DISTRICT 22 - MONTANA - All mines in the State

DISTRICT 23 - WASHINGTON
Washington - All mines in the State
Oregon - All mines in the State
Alaska - All mines in the State

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[25] Anon. Bituminous Coal and Lignite Distribution Calendar Year 1973. Bureau of Mines Mineral Industry Surveys, Division of Fossil Fuels. April 12, 1974. p. 3

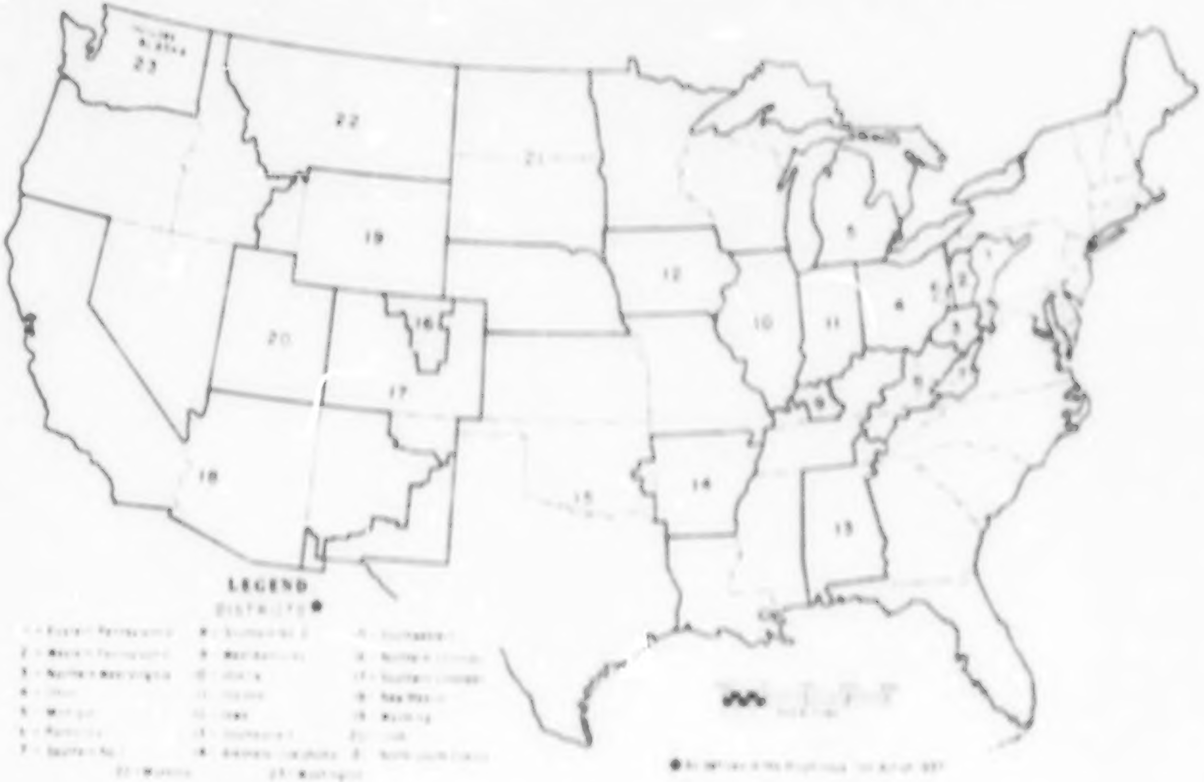
LEGEND
DISTRICTS
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Figure 21. Coal-producing districts of the United States[26]

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[26] Mutschler, P. H., R. J. Evans, and G. M. Larwood. Comparative Transportation Costs of Supplying Low-Sulfur Fuels to Midwestern and Eastern Domestic Energy Markets. Bureau of Mines Information Circular. 8614. 1973. p. 5.

Table 15. 1973 PRODUCTION AND CONSUMPTION BY STATE AND DISTRICT OF ORIGIN^{a,b}
(Total 1973 western coal production basis = 58,890 x 10^6 tons)^c

Point of Destination			Producing District^{d,e}													
			16		17		18		19		20		21		22 & 23	
State	Consumption (10^3 T)	% of Total	T	%	T	%	T	%	T	%	T	%	T	%	T	%
Illinois	[illegible]	[illegible]	*	*	[illegible]	[illegible]	*	*	*	*	*	*	*	*	4142	4142
Indiana	1782	[illegible]	*	*	*	*	*	*	*	*	*	*	*	*	1881	1682
Iowa	[illegible]	[illegible]	*	*	13	[illegible]	*	[illegible]	1915	[illegible]	*	*	*	*	*	[illegible]
Michigan	[illegible]	[illegible]	*	*	*	*	*	*	*	*	*	*	*	*	519	56
Minnesota	[illegible]	[illegible]	*	*	*	*	*	*	176	119	*	*	1382	NA	1784	NA
Missouri	[illegible]	[illegible]	[illegible]	*	11	[illegible]	*	*	[illegible]	[illegible]	*	*	*	*	*	*
Nebraska/ Kansas	[illegible]	[illegible]	*	*	190	NA	*	*	[illegible]	66	*	*	*	*	*	*
New York	71	[illegible]	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wisconsin	[illegible]	[illegible]	*	*	*	*	*	*	451	NA	*	*	*	*	33	NA
Totals	[illegible]	[illegible]	*	*	744	NA	*	*	4518	2971	71	0	1382	NA	11794	[illegible]
Arizona/ Nevada	4461	7.6	*	*	*	*	[illegible]	[illegible]	*	*	745	430	*	*	*	*
California	[illegible]	4.1	*	*	4170	[illegible]	*	*	*	*	1023	[illegible]	*	*	*	*
Colorado	[illegible]	[illegible]	104	55	4106	[illegible]	[illegible]	*	1594	56	*	*	*	*	[illegible]	*
Montana/Idaho	[illegible]	[illegible]	*	*	*	*	*	*	177	[illegible]	321	[illegible]	*	*	208	899
New Mexico	[illegible]	[illegible]	*	*	*	*	7181	7181	*	*	*	*	*	*	*	*
North/South Dakota	[illegible]	[illegible]	*	*	*	*	*	*	177	856	*	*	5424	5422	*	*
Utah	[illegible]	[illegible]	*	*	[illegible]	NA	*	*	31	[illegible]	2871	58	*	*	*	*
Washington/ Oregon	[illegible]	[illegible]	*	*	*	*	*	*	[illegible]	[illegible]	142	[illegible]	*	*	6174	5246
Wyoming	[illegible]	[illegible]	*	*	*	*	*	*	[illegible]	[illegible]	*	*	*	*	*	*
Totals	[illegible]	[illegible]	[illegible]	NA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% of Total to Producing District			[illegible]		[illegible]		[illegible]		[illegible]		9.3		[illegible]		[illegible]	

^{a}Includes California and [illegible]

^{b}[illegible] (MT)

^{c}Includes utility [illegible]

^{d}[illegible] pp. 4-15.

^{e}T = [illegible]

% = [illegible]

NA = not available

Table 16. COKING COAL PRODUCED IN THE WESTERN STATES WITH MAJOR COKING COAL SEAMS IN 1972[1,22]
(tons)

State	County	Seams	Production
Colorado	Gunnison	Somerset B, C and E	450,000
	Las Animas	Allen	616,000
	Pitkin	A & B, Upper Basin Bed	651,000
	Moffat	---	296,000
	Total		2,013,000
Montana	Cascade	Belt Creek	0
	Gallatin	No. 2	0
	Park	No. 1	0
	Total		0
New Mexico	Colfax	Raton and York	625,000
	Sante Fe	Cook and White	0
	Socorro	Carthage	0
	Total		625,000
Utah	Carbon	Black Diamond, C, Clear Creek, Kenilworth, Sunnyside	1,872,000
	Emery	Sunnyside	0
	Total		1,872,000
Washington	King	Snoqualmie Nos. 3, 4 & 5	29,000
	Kittitas	Roslyn Nos. 5 & 6	0
	Pierce	Nos. 1, 2, 3, 4, 5 & 7 (Fairfax-Montezuma area); Nos. 1, 2, 3, 4, 4-1/2, 5 6 & 7 (Melmont); Nos. 2, 6, 7, 8, 13, 14, 16 & 21 (Wilkeson-Carbonado Carbo River field)	0
	Skagit	No. 1 or Klondike, No. 2 or Middle Vein (Cokedale area); Nos. 1, 2, 3 & 4 (Hamilton)	0
	Whatcom	Blue Canyon	0
	Total		29,000
TOTAL COKING COAL			4,539,000

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[1] pp. 398-402.

[22] pp. 452-453.

Table 17. AVERAGE VALUE OF BITUMINOUS COAL AND LIGNITE, F.O.B. MINE[22]

State	1971				1972			
	Underground	Strip	Auger	Total	Underground	Strip	Auger	Total
Arizona	-	W[a]	-	W[a]	-	W[a]	-	W
Colorado	7.80	3.91	-	6.34	8.34	4.10	-	6.45
Montana								
Bituminous	9.33	1.79	-	1.79	9.74	2.00	-	2.01
Lignite	-	2.27	-	2.27	-	2.45	-	2.45
Total	9.33	1.79	-	1.82	9.74	2.01	-	2.03
New Mexico	8.05	2.61	-	3.26	10.42	2.66	-	3.61
North Dakota								
Lignite	-	1.91	-	1.91	-	2.02	-	2.02
Utah	7.37	8.00	-	7.37	8.93	8.00	-	8.93
Washington	13.55	6.52	-	6.72	16.40	6.51	-	6.61
Wyoming	6.25	3.35	2.20	3.39	4.89	3.69	-	3.74
U.S. Average	8.27	5.19	6.57	7.07	9.70	5.48	6.54	7.66

[a] W = Withheld to avoid disclosing individual company confidential data

[22] p. 386.

heating qualities. Coal prices fluctuate widely due to many complex interactions, some of which involve coal miner strikes and market demand fluctuations.

The average prices shown in Table 17 should be considered conservative. Some local prices have been inflated to two and three times the average prices. Appendix E gives a further breakdown of western coal prices by county.

3.4 CONSIDERATIONS AFFECTING THE SELECTION OF WESTERN COAL MINE SITES

Major factors influencing the decision to mine western coals for steam generation are reviewed here. It is assumed, as indicated previously, that adequate reserves of both coal and water are available, and these are not factors in mine site selection. Basic economic aspects of coal mining methods are presented along with ancillary considerations that contribute to the success or failure of a mining venture. Current trends have been toward strip mining because of the thick coal seams near the surface and the ease of recovering the coal. Due to the vast quantities o higher quality deep minable steam coal resources, an economic analysis of underground mining considerations is also presented along with the strip mining analysis.

The factors that influence western coal development are broken into three major categories: economic, technological, and governmental. Table 18 gives economic variables relating to both underground and surface mining. Tables 19 and 20 respectively list technological and governmental aspects peculiar to underground and surface mining. Strip and auger mining factors are included under the surface mining classification.

Table 18. ECONOMIC COST VARIABLES INFLUENCING GRASS ROOTS WESTERN STEAM COAL MINING DEVELOPMENT

External Factors[a]	Internal Factors[b]
Heating value	Exploration
Sulfur restrictions	Construction
Haul distance	Development
Ash content	Mining equipment
Moisture content	Engineering
	Available manpower
	Operating supplies
	Wages
	Union welfare
	Coal royalties/leases
	Taxes
	Insurance
	Depreciation
	Power/fuel
	Post treatment requirements
	Reclamation
	Coal storage handling
	Mining method[c]
	Stripping ratio[d]

[a] Cost factors that contribute to the success or failure of the venture as a whole.

[b] Costs maintained in the operation of a mine.

[c] Deep: conventional, continuous, longwall; Strip: contour, area, auger/strip.

[d] Strip mining only.

Table 19. TECHNOLOGICAL VARIABLES INFLUENCING GRASS ROOTS WESTERN STEAM COAL MINING DEVELOPMENT

Underground Mining	Surface Mining
Roof support	Overburden characteristics
Underground geological structure	Seam thickness
Methane evolution	Equipment size, type and quantity
Equipment size, type and quantity	Weather
Coal abrasiveness	Reclamation requirements
Underground water removal	Available transportation
Power availability and transmission	Topography and pitch of coal seams
Available transportation	Slope angle
Coal storage	Pit dimensions
In-ground coal recovery percentage	Power availability and transmission
Refuse disposal	Coal Storage
Water quality control	Land use after mining
	Water quality control
	Roads
	Refuse disposal

Table 20. GOVERNMENTAL LEGISLATION INFLUENCING GRASS ROOTS WESTERN STEAM COAL MINING DEVELOPMENT

Underground Mining	Strip Mining
EXISTING	
Federal Coal Mine Health and Safety Act of 1969	Federal Antiquities Act of 1906
Federal Antiquities Act of 1906	Mineral Leasing Act of 1920
Mineral Leasing Act of 1920	State regulations
State regulations	Federal regulations
Federal regulations	
PENDING	
State regulations	Energy Supply and Environmental Coordination Act of 1974
Federal regulations	State regulations
	Federal regulations

3.4.1 Western Coal Mining Economics

As with any large industrial venture, it is the production economics that ultimately decide success or failure. Underground coal mining costs usually center around labor issues because of the large number of personnel required. The need for the evolution of bigger and more efficient stripping draglines and related coal and earth moving equipment has made strip mining largely equipment intensive.

Breakdowns of various capital cost percentages typically involved in the setup of various size western strip mines and one deep mine are shown in Table 21. Mining via continuous mining machines was assumed for the deep mine costs. Mining via conventional dragline and stripping shovel combinations was assumed for the strip mining cases. No coal washing or post treatment costs were involved in the calculations. It is evident from these limited data why strip mining is economically attractive. For nearly the same capital investment required for a Utah underground mine one can develop a Montana or Wyoming strip mine with 2.5 times the production capacity. The large capital cost of underground development is also eliminated by strip mining.

However, capital investment varies markedly from region to region for strip mining. The lowest capital investment appears to be in Montana ($13,879,100) and the highest in the southwest ($28,656,700) for equal strip mine production capacity (5 MM tons/year). Table 21 demonstrates that strip mining is largely equipment intensive as witnessed by the nearly constant direct cost percentage with essentially doubled total capital investment. The size and number of

Table 21. ESTIMATED CAPITAL REQUIREMENTS FOR SURFACE AND UNDERGROUND WESTERN COAL MINES[14,27]

(% of base)

	Region						
	Utah	Arizona Colorado New Mexico Utah	Arizona Colorado New Mexico Utah	Montana	Wyoming	North Dakota Montana	North Dakota Montana
Production capacity (MM/yr)	7.0	1.5	5.7	5.0	5.0	1.0	1.0
Type mine	deep	strip	strip	strip	strip	strip	strip
Life expectancy (yr)	15	20	20	20	20	20	20
Base ($)	13,426,479[a]	7,898,100[b]	28,656,700[b]	13,879,100[b]	13,921,100[b]	6,[illegible][b]	20,749,700[a]
Direct (mining equipment, buildings, exploration	59.6	74.6	74.7	73.5	73.2	74.6	74.4
Field indirect construction	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Engineering	1.9	1.5	1.5	1.5	1.5	1.5	1.5
Overhead/administrative	2.0	3.9	3.9	3.8	3.8	3.9	3.9
Contingency	6.9	8.1	8.1	8.0	8.0	8.[illegible]	8.1
Interest during construction	1.8	2.3	2.3	2.1	2.2	2.[illegible]	2.3
Working capital	8.5	6.3	6.8	7.7	8.8	6.2	6.5
Fee	NA	1.8	1.8	1.8	1.8	1.[illegible]	1.8
Underground development	13.7	NA	NA	NA	NA	NA	NA

[a] 1975 dollars.

[b] 1969 dollars.

NA not applicable

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[14] pp. 5-11.

[27] Anon. Cost Analyses of Model Mines for Strip Mining of Coal in the United States. Bureau of Mines Information Circular. 8535. 1972. 115 p.

overburden removing draglines in a mining operation have a major influence on capital costs. The Montana 5.0 million ton per year model employs only one ($5 x 10⁶) large dragline while the southwestern operation used three ($15 x 10⁶). The main factors contributing to the wide differences in strip mining capital costs are local topography and degree of mining difficulty peculiar to a region.

Coal selling prices are primarily influenced by production costs. Annual production costs for these same hypothetical mines are shown in Table 22. It is seen that despite the high cost per ton of underground coal, it appears to be competitive with strip mined coal on a cost per Btu basis except for the Montana/Wyoming coals. Wide differences exist between base production costs per ton for strip mines of equivalent capacity. These differences are caused by the complex interaction of the variables listed in Table 18.

Several cost items can serve as examples. The contribution to the United Mine Workers Welfare Fund is $0.40/ton for bituminous and subbituminous coal and $0.20/ton in the lignite fields of North Dakota/Montana.[27] Many western strip mine operators escape this cost by employing miners who belong to either the International Union of Operating Engineers or to no union at all. Payment of royalties to owners of the coal other than the coal company varies widely ($0.15 to $0.28 per ton). Deferred expenses, including reclamation

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[27] pp. 1-6

Table 22. ESTIMATED ANNUAL PRODUCTION COSTS FOR SURFACE AND UNDERGROUND WESTERN COAL MINES[14,27] (% of base)

	Location						
	Utah	Arizona Colorado New Mexico Utah	Arizona Colorado New Mexico Utah	Montana	Wyoming	North Dakota Montana	North Dakota Montana
Production capacity (10⁶ t/yr)	2.0	1.0	5.0	5.0	5.0	1.0	5.0
Type mine	deep	strip	strip	strip	strip	strip	strip
Life expectancy (yr)	15	20	25	25	25	25	30
Btu/lb (as received)	12,094	10,000	10,000	8500	8[illegible]	7200	7200
Base (¢/10⁶ Btu)	12.7^a	14.[illegible]^b	11.9^b	8.2^b	9.[illegible]^b	[illegible]^b	11.7^b
Base ($/ton)	3.07^a	3.[illegible]^b	2.40^b	1.39^b	1.5[illegible]^b	[illegible]^b	1.64^b
Direct							
Labor	24.5	16.[illegible]	25.6	15.8	12.5	[illegible]	20.7
Operating supplies	26.6	21.9	27.5	24.5	23.5	[illegible]	25.6
Power	3.1	5.0	6.7	[illegible].2	3.8	[illegible]	8.1
Indirect							
Union welfare	12.4	19.[illegible]	16.7	14.4	25.3	5.9	12.9
Payroll overhead	7.4	5.6	3.3	3.6	3.9	7.2	3.6
% of labor, maintenance & supplies	NA	5.6	5.8	5.8	5.1	5.[illegible]	5.4
Royalty	4.7	5.9	7.5	16.5	12.0	7.6	20.7
Fixed							
Depreciation	11.8	20.[illegible]	12.5	13.6	10.7	19.[illegible]	19.1
Deferred expenses (reclamation, power lines)	11.2	6.6	5.8	5.0	4.4	6.8	4.9
Taxes, insurance	1.9	4.6	4.2	4.6	3.2	4.6	4.2
Interest on working capital	1.6	NA	NA	NA	NA	NA	NA

^{a}1972 dollars. NA not available

^{b}1969 dollars.

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[14]pp. 8-21.

[27]pp. 69-116.

and power line setup, vary because some states have strict reclamation laws and because power line setup costs are largely dependent on line distance and local wage rates. The cost to level spoil banks and replant can amount to as much as $0.15 per ton. More stringent reclamation regulations can force this figure as high as $1.00 per ton of mined coal.[28]

Mining coal reserves with thick seams is of utmost importance to the economic success of western surface mines. The large transportation distances and associated cost must be offset at the mine by low overburden to coal ratios. In the five major states where surface coal mining predominates (Arizona, Montana, New Mexico, North Dakota, and Wyoming) the overburden is relatively thin. No more than 200 feet of rock and soil overlie the majority of strippable reserves in these states. As of 1973 most current mining removes only 30 to 80 feet of overburden. The thickness of coal seams, some of which are over 100 feet, lowers the overburden to coal ratio substantially in comparison with eastern coals. Overburden to coal ratios in the west (stripping ratio) are frequently less than 1:1 and seldom exceed 7:1.

Table 23 shows typical thicknesses of coal seams currently surface mined in the West.

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[28] McLean, J. G., Chariman. U.S. Energy Outlook - A Report of the National Petroleum Council's Committee on U.S. Energy OUtlook. National Petroleum Council. December 1972. p. 145.

Table 23. SURFACE COAL SEAM THICKNESS[20]
(feet)

	Maximum	Minimum	Average
Wyoming	118	6	70
Montana	60	5	25
North Dakota	27	5	16
New Mexico	15	4	11
Arizona	30	4	10

[20] p. 3.

Taxes previously have been an insignificant part of the coal production cost, but this is changing. Two states in particular (Montana and Wyoming) are imposing strict taxes on coal to provide revenue for reclamation and environmental studies.

The January 9, 1973 Montana legislative session has had a significant effect on the outlook of coal development. The 1973 session passed the Mining License Tax Act which increased the 8¢ per ton tax to the following, based on Btu:[29]

Btu	¢/ton
7000 or less	12
7000 to 8000	22
8000 to 9000	34
9000 or more	40

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[29] Rawlins, J. H. Montana: Legislators Give the State Control Over Surface Mine Siting. Coal Age. 79:86-88, May 1974.

The Resources Indemnity Trust Fund Tax is a tax on minerals extracted to provide a fund for reclaiming land where the operator does not fulfill his obligations. The tax is 1/2 of 1% of sales price. Along with the existing property taxes and Net Proceeds of Mines Tax (excise tax on assessed value of production) the total taxes paid in Montana on coal ranges from 27¢ per ton to 74¢ per ton.[29]

Wyoming raised the excise tax levy from 1% to 3% in 1973.[30] Gross production taxes increase yearly as total production valuation increases. An annual fair cash market value is affixed to the produced coal f.o.b. mine by the Wyoming Department of Revenue. A mill levy is then introduced by the county to arrive at a tax on its gross production. In 1972 the revenue from this tax averaged 11¢ per taxable ton of coal mined.[30] This rate should increase markedly simply because 1974 Wyoming coal sells for $2.50 to $2.88 a ton. Production and excise taxes are expected to reach 30¢ to 38¢ per ton in 1974.[30] Pending ballot legislation calls for an amendment entitled House Joint Resolution No. 2A that would set aside 1.5% of the new excise tax for a Permanent Wyoming Mineral Trust Fund that would serve as a hedge against future lowered assessed valuations.[30]

Because of the economy of scale seen in strip operations, most mine owners opt for large operations in an attempt to offset these types of costs. Underground mining is seen to be considerably more labor intensive than strip mining, and the skilled manpower shortage in the West is certain to adversely affect the smooth growth of underground mines. Direct labor costs for both types of mining methods are deflated because they do not reflect substantial wage increases resulting chiefly from the United Mine Workers of America Wage Contracts of 1971 and 1974. The 1971 contract provided for labor cost increases of 39% for strip and deep mine workers over a 3-year period.[31] Additionally, the 23 day strike by coal mines in late 1974 will have a detrimental effect on future mine development for mines employing UMWA workers. The total increase in labor costs for the 1974 three year contract has been calculated to be 64.6% over those of the 1971 contract.[32] The employment of workers belonging to less powerful unions or no union at all is expected to increase in the future to defray these costs. The Federal Coal Mine Health and Safety Act of 1969 has decreased the level of productivity of deep coal mines. This forces coal mine labor reserves to increase in order to maintain productivity. However, shortages of skilled manpower defeats labor increases. The majority of underground mines in the West mine high priced metallurgical coking coal rather than steam coal. It is unlikely that future deep mines will supply a large portion of coal unless environmental and reclamation strip mining regulations significantly shift economics in their favor, or until the underground techniques such as longwall mining, that can increase production per man-shift are accepted.

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[29] p. 87.

[30] Glass, G. B. Wyoming: Production Seen Doubling by 1976. Coal Age. 79:98-99, May 1974.

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[31] McClung, J. D., and K. K. Humphreys. Is the Energy Crisis Real? American Association of Cost Engineers Bulletin. 15(3):77, June 1973.

[32] Anon. New Labor Contract Provides Wages, Safety, Pension Improvements. Coal Age. 80:57-59, January 1975.

3.4.2 Western Coal Mining Technology Forecast

Conventional room-and-pillar and continuous underground mining operations generally leave up to 50% of the coal mine reserve in place in the form of pillars and supports.[28] Strip mining by conventional techniques recovers 90% or more of the original in-place coal reserve.[28] Longwall underground mining technology improves the recovery factor and productivity substantially (90%) but is largely untested in the West and cannot be used in certain underground rock structures. The fact that only approximately 10% of the total U.S. coal resources lie within 150 feet of the surface (maximum economic and practical stripping depth) precludes strip mining from a major role in the ultimate recovery of American coal.[33] Long-range planning thus points to the reemergence of underground mining methods. Longwall stripping methods for surface mining are being investigated by EPA. This promising mining method would minimize surface disturbance (see Section 5).

The present trends indicate the continuance of larger and more efficient strip operations. The main limiters of this trend are governmental policies, public sentiment, manpower, and equipment availability.[28] Stripping operations with built-in reclamation programs are necessary if current strip mining growth is to continue. The thick seams of coal (some can average over 100 feet) counter the current reclamation technology. Grading the mined out areas back to original contours requires that fill dirt be trucked in from other sources.

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[28] pp. 140, 140, 27.

[33] Nephew, E. A. The Challenge and Promise of Coal. Technology Review. 76(2):27, December 1973.

3.4.3 Western Coal Mining Legislation

3.4.3.1 Existing legislation - surface mining -

Federal and state provisions regulating surface coal mining are in continual flux. Federal and state regulations are presented in Appendix F. These regulations were in effect as of 1972 and as such do not represent the latest thinking in this area. Nearly 65% of the western coal lands are regulated by specific state laws and/or Indian agreements. The remaining 35% are under the less specific Federal regulations.[34] As of 1971 those western states with no state strip mining regulations *per se* were Arizona, New Mexico, Oregon, South Dakota, and Utah.

Existing federal regulations provide for reclamation plans to be filed with the Mining Supervisor showing methods and timing of grading and backfilling areas affected by the mining operation. The reclamation plan also shows the method of preparing the soil prior to replanting. In lieu of execution of the plan, the $2000 bond paid by the operator is forfeited, and the lease is cancelled. State laws are similar in scope. In certain instances, both state and federal regulations appear unclear with reference to grading to original contours and successful revegetation in the arid west. Most state laws governing surface mining and rehabilitation in the West do not provide for adequate planning, monitoring, enforcement and financing of rehabilitation.[35]

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[34] Anon. The Coal Industry's Controversial Move West. Business Week. pp. 134-138, 138. May 11, 1974.

[35] Box, T. W. Land Rehabilitation: Prompt Passage of Federal Reclamation Law Recommended by Ford Foundation Study. Coal Age. 79:116, May 1974.

The Federal Antiquities Act of 1906 requires that the historical nature of lands be explored before mineral deposits are excavated. This act applies to both surface and underground mining. The West is rich in archaeological artifacts and the coal operator must partially or totally finance the exploration and artifact recovery operations.

Water allocation laws are also strict in most western states due to potential shortages in the arid West. The requirements of water for mining are presented in Section 3.4.5. In some areas the coal seams themselves form part of the aquifers.[34] Montana, concerned that its farmers will not have enough irrigation water, has declared a 3-year moratorium on any new commitment of water from rivers in eastern Montana.[34]

3.4.3.2 Existing legislation - underground mining -

The Federal Coal Mining Health and Safety Act of 1969 has been the major obstacle in the development and production of deep mines to date. The major items included in this act are summarized briefly as follows:[36]

1. Lower respirable dust levels
2. Lower noise levels
3. Better roof supports
4. Increased ventilation
5. Monitoring of methane emissions

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[34] pp. 138, 138.

[36] 91st Congress, The Federal Coal Mining Health and Safety Act. Public Law 91-173, Sec 2917, (1969) pp. 1-60.

6. Improved rock dusting
7. Safer electrical equipment
8. Fire protection
9. Detailed escape routes
10. Blasting limitations
11. Black lung benefits for afflicted miners

3.4.3.3 Recent coal lease legislation -

Under the Mineral Leasing Act of 1920 coal prospecting and mining are allowed on public land on a lease basis with minimum annual rentals (25¢ per acre for the first year, 50¢ per acre for years two through five, $1 per acre for years six and after) and royalties (5¢ per ton minimum).[37] The limit on noncontiguous lease holdings currently is 46,080 acres per state per person.

New coal leasing policies were recently announced by the Department of the Interior. A moratorium on both pending and future prospecting permits is in effect until the supply-demand situation is more thoroughly defined.[37] The objectives of the new federal policy are: (1) to assure maximum environmental protection, (2) to provide for orderly and timely resource development, and (3) to assure a reasonable return for resources sold.

3.4.3.4 Recent and pending legislation - surface mining -

Both federal and state legislatures have numerous land-use and water bills pending covering environmental concerns and much needed resource regulation. Colorado's legislature, for example, has over 25 land-use bills pending. Both the U.S. Senate and the House of Representatives are actively engaged in strip mining legislation. A senate bill passed in the fall of 1973 would require strip miners to return the land they dig up to roughly its original condition.[38] The high cost of reclamation may well significantly alter the way the U.S. exploits its energy resources. A house bill similar to the senate bill, passed in late July of 1974 (H.R. 11500), also bars strip mining in the arid and semi-arid alluvial valleys of the West, and it forces mining companies to get permission from ranchers before mining federally leased coal from under their land.[38,39]

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[37] 93rd Congress, Factors Affecting the Use of Coal in Present and Future Energy Markets. Pursuant to State Resolution 45. Dockett #93-9(92-44), (1973) pp. 20-22.

Montana has taken the lead in passing severe environmental legislation. The 1973 Montana Strip Mining and Reclamation Act provides for the control of prospecting and strip mining. It sets forth stricter provisions for permit requirements, reclamation plan requirements, methods of operation, penalties and other controls.[29] The 1974 Montana Strip Mine Siting Act allows the state to approve or disapprove the plans for new surface mining operations prior to any development and large-scale investments.[29] The 1974 Coal Conservation Act would require that higher royalties be paid if only the uppermost seams are mined. The incentive for coal operators in Montana would be to mine all coal seams, thus preventing restripping of an area.[29] A 3-year water moratorium has been imposed on large volume water use applications in the Yellowstone River drainage basin in Montana. The suspension will provide time to study future water usage.[29]

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[38] Anon. Going Underground. Newsweek, August 5, 1974, pp. 53-54.

[39] Anon. Hosmer Calls Strip-Mining Bill 'Congressional Embargo.' Energy Digest. 4(11):235, July 15, 1974.

[29] pp. 86-88.

3.4.3.5 Recent and pending legislation - underground mining -

Following closely behind pending legislation on strip mining is legislation aimed at cleaning up underground mining operations. Specific bills are certain to be enacted by state legislatures on such topics as coal refuse fires and gob pile disposal. Acid mine drainage is not expected to be of major concern legislatively because of western coal's inherently low inorganic sulfur content.

3.4.4 Evaluation of Western Coal Mining Development Factors

The primary factors inhibiting the development of new western coal mines are:

a. Legislative uncertainties concerning a ban of all western strip mining

b. High costs of reclamation to original topography

c. Strip and deep mining new equipment availability

d. Transportation uncertainty and long haul economics

e. Skilled manpower shortage and wage changes

f. Lack of new mining technology emphasis (e.g. longwall mining, co-current reclamation/strip mining)

g. High capital investment which excludes the small mine operator.

Mine development hinges on the above factors as well as on establishing relationships with utility companies that are in dire need of low sulfur coal now (Section 3.3).[40] Quoting from Eli Goldston, Chairman of the Board, Rocky Mountain Associated Coal Corporation (1972): "Recover coal from shallow surface mines first, then move on to the deeper surface mining and ultimately to the deep mining because the vast percentage of the total reserves are deep mining reserves."[40]

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[40] Goldston, E. Economic Aspects in Developing Coal in the Rocky Mountains. Coal Age. 77:86, March 1972.

3.4.5 Water Requirements and Availability

Western coal mining operations require water for the following applications:

a. Land revegetation
b. Pipeline slurry transportation
c. Dust control on haul roads and in mines (underground)
d. Coal cleaning operations
e. Potable supply

Water is scarce in most of the ten states included in this study. Water usage in mining operations is quantified in a general sense here, and areas of severe water deficiency are defined. Water appropriation and allocation is very complex in the West. New industrial ventures such as coal mining experience difficulty in obtaining water rights. While the above water needs are admittedly low in comparison to mine-mouth power plants and coal gasification requirements, it is felt that water acquisition is a vital factor to consider in determining future utilization and mining of the western coal deposits.

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[40] p. 86.

The success of land revegetation depends primarily on the availability of water in the arid and semi-arid West and on soil and areal characteristics that permit moisture retention and promote growth. Rainfall is the most reliable indicator of successful probability of growth although irrigation can augment revegetation. Annual mean precipitation in the West is low ranging from 4 inches or less in some of the hot deserts to 20 inches or more in the higher mountains.[35] Droughts are common. Precipitation may come as high intensity, short duration storms or as snowfall. Those areas receiving less than 10 inches of annual rainfall are generally considered to require major, sustained input of water, fertilizer and management.[35] Areas with high evapo-transpiration rates (i.e., inability of soil to retain moisture combined with water loss from plants) are classified similarly. The figure of 10 inches of annual rainfall is not a hard and fast rule since many other variables are involved in successful plant growth.

Figure 24 shows that portions of Arizona, Utah, Wyoming, Washington, and Oregon have rainfalls from 0 to 10 inches annually. The ability of an area to lose water by evapotranspiration is shown in Figure 25. The greater this value, the less water becomes available for use. In arid regions the increased loss may be so great that it significantly diminishes the value of a reservoir used to regulate the water supply.[41] Figure 26 shows areas in which natural water surplus

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[35] pp. 109, 109.

[41] p. 3-2-3.

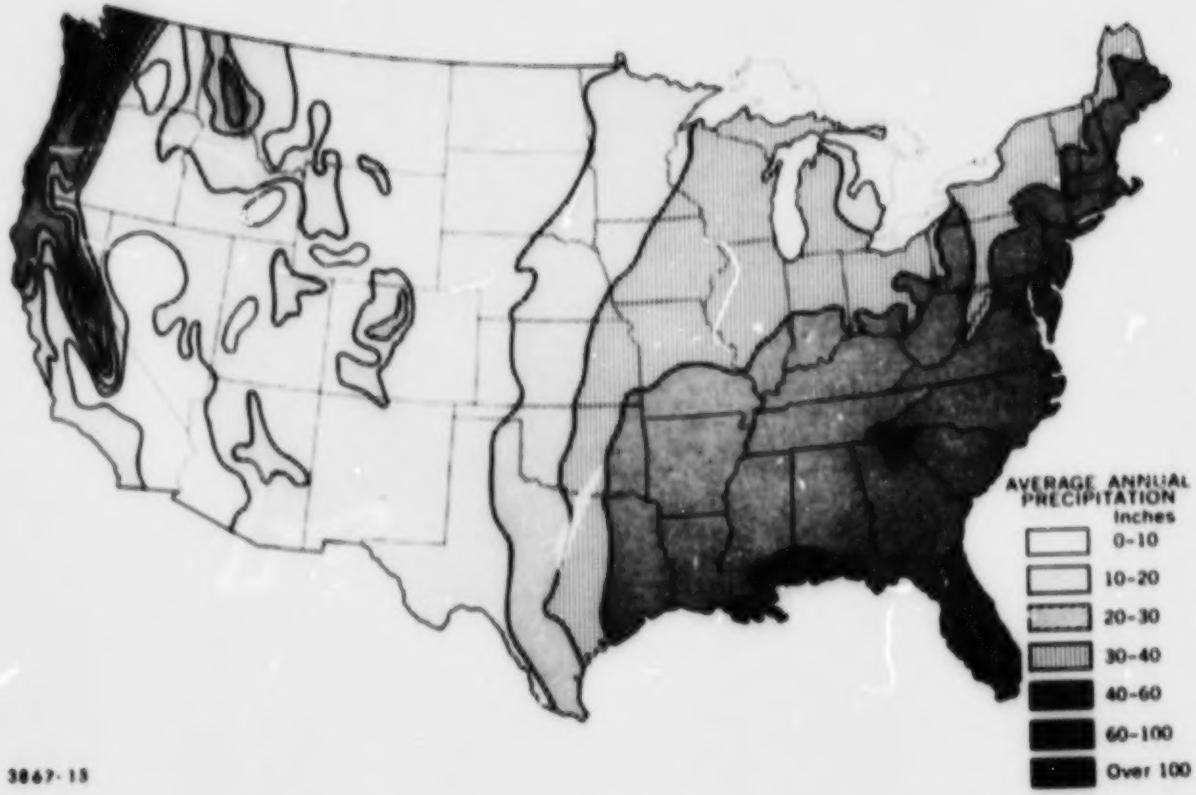
AVERAGE ANNUAL PRECIPITATION
Inches
0-10
10-20
20-30
30-40
40-60
60-100
Over 100
3867-13

Figure 24. Average annual precipitation[41]

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[41] p. 3-2-2.

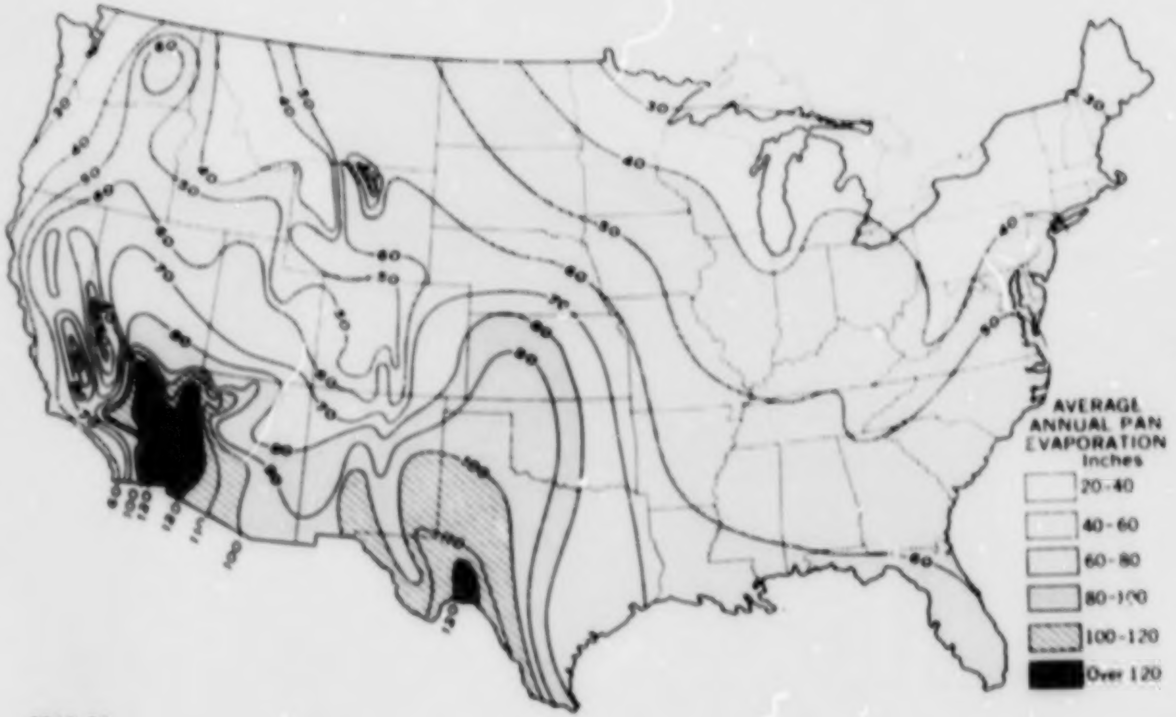
AVERAGE ANNUAL PAN EVAPORATION
Inches
20-40
40-60
60-80
80-100
100-120
Over 120
3867-16

Figure 25. Average annual pan evaporation[41]

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[41] p. 3-2-3.

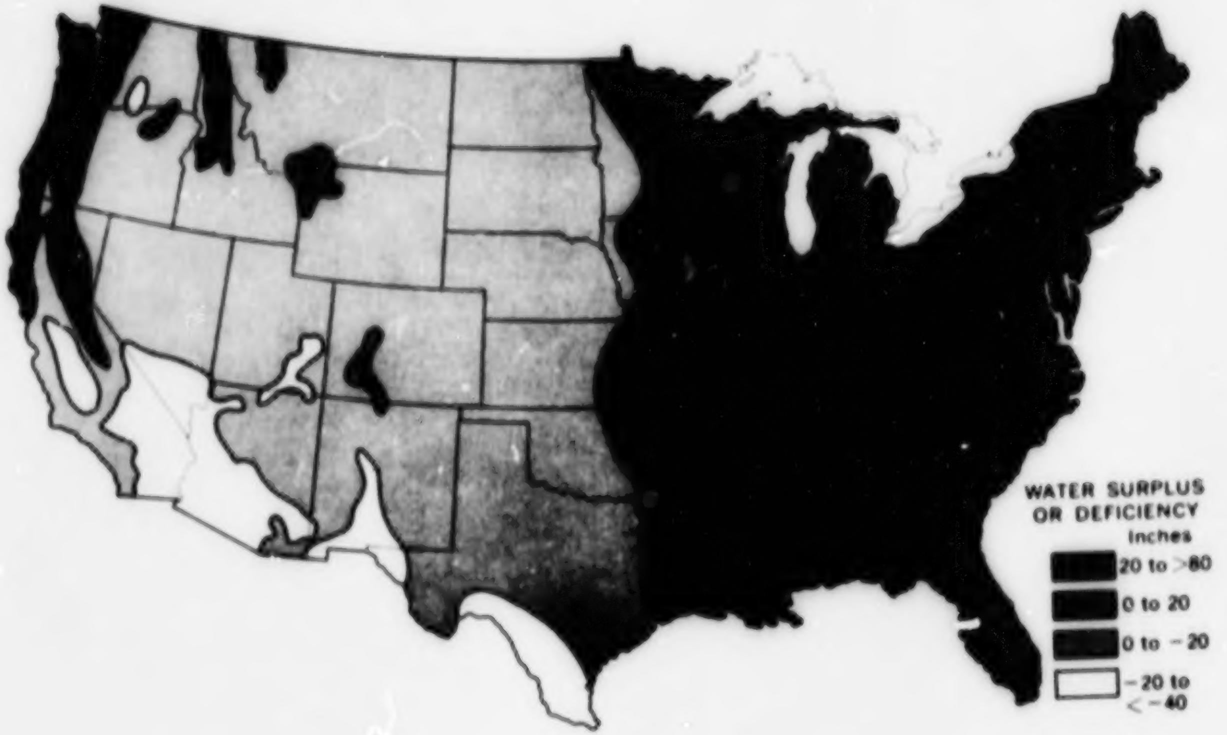
WATER SURPLUS
OR DEFICIENCY
Inches
20 to >80
0 to 20
0 to −20
−20 to
<−40

Figure 26. Areas of natural water surplus and natural water deficiency[41]

or water deficiency commonly exist. The values shown have been computed by subtracting evapo-transpiration from average precipitation. Short-term seasonal deficiencies can occur in areas of surplus.

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[41] p. 3-2-4

The river and stream runoff in the West is tighly controlled by appropriation rights. The Appropriation Doctrine developed and used in the U.S. over the past hundred years states that the first one who applies water to a beneficial use acquires the first right to the use of that water regardless of the location of use and regardless of the ownership of the lands adjoining the stream.[42] In contrast, the Riparian Doctrine gives to the owners of the land adjoining a stream the exclusive right to the use of the water. Water for western irrigation including ground water also falls under the Appropriation Doctrine. Variations of the doctrine are also practiced but they are similarly stringent. Figure 27 shows present conventions in water rights laws as they apply to different regions of the country.

The dependable water supply from rivers and streams in the West is able to keep pace with the water withdrawn and consumed as shown in Figure 28. Water withdrawn is the amount of water utilized from the water reservoir for any purpose excluding hydroelectric power. Consumption refers to amount of water withdrawn but not directly returned to the supply. The ratio of water supply to water use using the 1980 dependable supply figures is 3.3 for the non-coastal western states. Obviously higher dependable water supplies exist for

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[42] Moses, R. J. Where is the Water Coming From? Chemical Engineering Progress Technical Manual - Cooling Towers. AIChE Publications. 1972. p. 42.

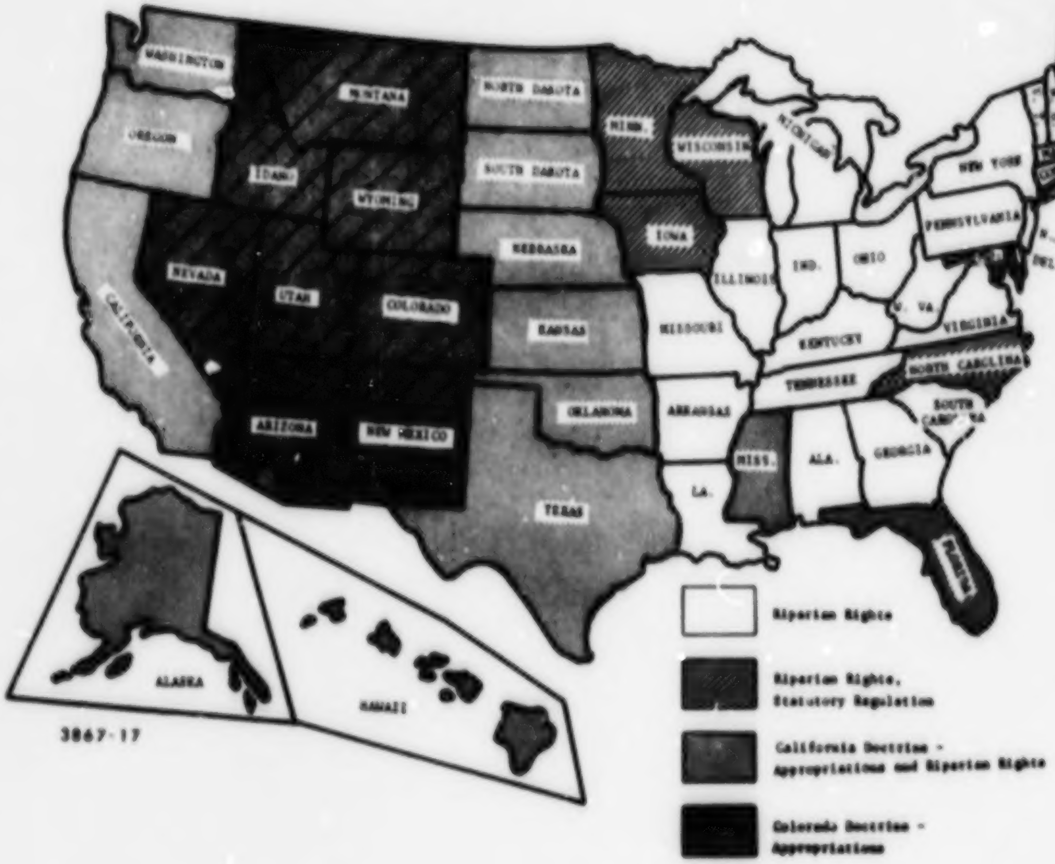
WASHINGTON
OREGON
CALIFORNIA
MONTANA
IDAHO
WYOMING
NEVADA
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINN.
WISCONSIN
IOWA
MICHIGAN
ILLINOIS
IND.
OHIO
MISSOURI
KENTUCKY
ARKANSAS
TENNESSEE
MISS.
ALA.
GEORGIA
LA.
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W. VA.
PENNSYLVANIA
NEW YORK
MAINE
R.I.
N.J.
DEL.
ALASKA
HAWAII
3867-17
Riparian Rights
Riparian Rights, Statutory Regulation
California Doctrine - Appropriations and Riparian Rights
Colorado Doctrine - Appropriations

Figure 27. Present conventions in water rights law[42]

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[42] p. 42.

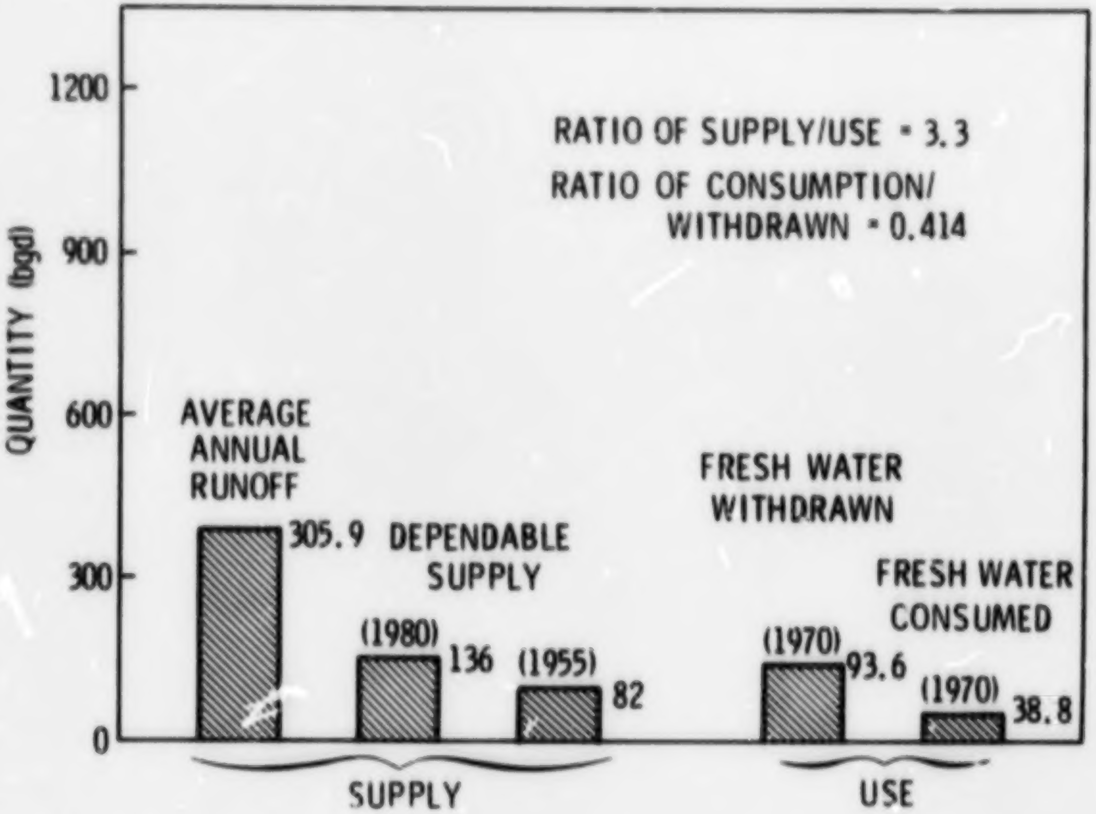

Figure 28. Water supply and demand in the non-coastal western state[43]

the U.S. as shown in Figure 29. However, the ratio of water supply to water use is only slightly higher, averaging 3.8. Where the potential problem exists is in the rate of water consumption to water withdrawals in the West. Comparing Figures 28 and 29 it is seen that the ratio of western consumption to withdrawal is nearly twice that of the entire U.S. (0.414 vs 0.238). This is probably explained by vast consumptive usage of water for crop irrigation, dust control, etc.

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[43] Murray, C. R. Water Use, Consumption, and Outlook in the U.S. in 1970. J. American Water Works Association. 65:307, May 1973.

The variability of major river flow is also a significant problem in the West. This is a strong indicator of dependable water supply. Figure 30 shows the water resource regions of the U.S. Table 24 gives figures for mean annual natural runoff for each region shown in Figure 30. The average runoffs available for 50%, 90% and 95% of the years are computed from statistical distributions of annual runoffs at gaging stations. The closer the 95% figure is to the mean value, the lesser variability is experienced throughout the year. For example, the average runoff available in 95% of the years in the humid North Atlantic Region is 69% of the mean. The arid lower Colorado Region has only 26% of the mean available 95% of the years. The areas of greatest variability in annual runoff are in the southwest and west-central parts of the United States.[41] In general, potential water availability in the West from rivers is not very promising because of prior allocation, and it is not totally reliable because of great fluctuations in stream flow.

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[41] pp. 3, 2, 6.

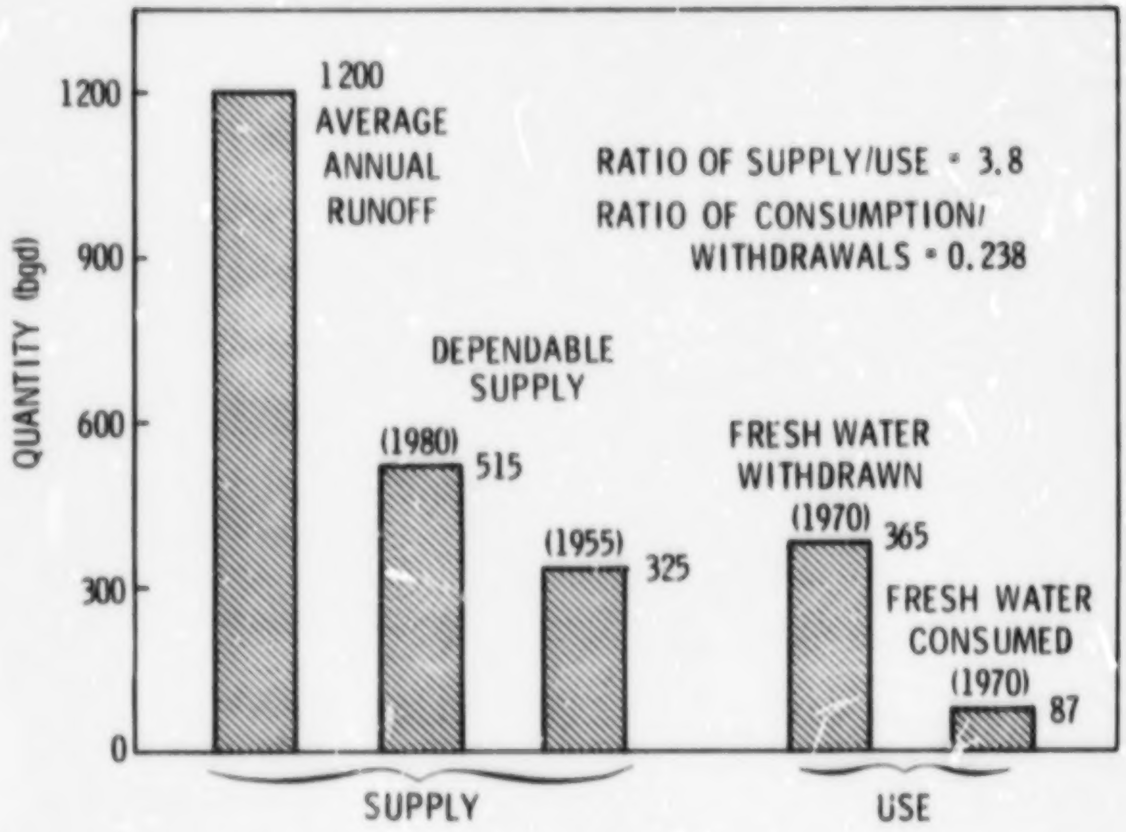

Figure 29. Water supply and demand in the 48 conterminous states[43]

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[43] p. 307.

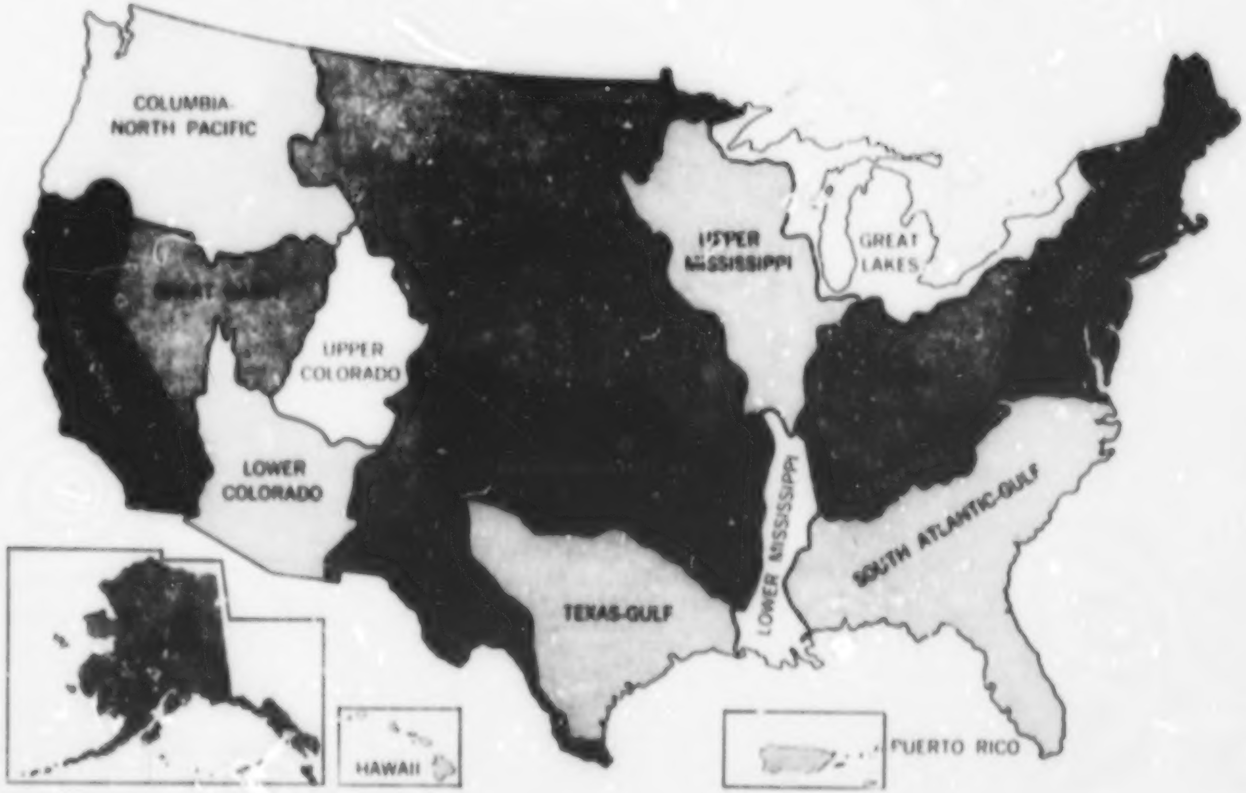
COLUMBIA-
NORTH PACIFIC
GREAT BASIN
UPPER
COLORADO
LOWER
COLORADO
UPPER
MISSISSIPPI
GREAT
LAKES
LOWER MISSISSIPPI
TEXAS-GULF
SOUTH ATLANTIC-GULF
HAWAII
PUERTO RICO

Figure 30. Water resources regions for water use in the United States[41]

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[41] p. 2-3.

Table 24. ANNUAL NATURAL RUNOFF[41]
(billions of gallons per day)

Region	Mean	50%[a]	90%[a]	95%[a]	% of Mean[i]
North Atlantic[b]	163	163	123	112	69
South Atlantic-Gulf	197	188	131	116	59
Great Lakes[b,c]	63.2	61.4	46.3	42.4	67
Ohio[d]	125	125	80.0	67.5	54
Tennessee	41.5	41.5	28.2	24.4	59
Upper Mississippi[d]	64.6	64.6	36.4	28.5	44
Lower Mississippi[d]	48.4	48.4	29.7	24.6	51
Souris-Red-Rainy[b]	6.17	5.95	2.60	1.91	31
Missouri[b]	54.1	53.7	29.9	23.9	44
Arkansas-White-Red	95.8	93.4	44.3	33.4	35
Texas-Gulf	39.1	37.5	15.8	11.4	29
Rio Grande[e]	4.9	4.9	2.6	2.1	43
Upper Colorado[f]	13.45	13.45	8.82	7.50	56
Lower Colorado[d,e]	3.19	2.51	1.07	0.85	26
Great Basin[d]	5.89	5.82	3.12	2.46	42
Columbia-North Pacific[b]	210	210	154	138	66
California[e]	65.1	64.1	33.4	25.6	39
Conterminous U.S.[g]	1,201				--
Alaska[b]	580	(h)	(h)	(h)	--
Hawaii	13.3	(h)	(h)	(h)	--
United States[g]	1,794				--

[a] Flow exceeded in indicated percent of years.

[b] Does not include runoff from Canada.

[c] Does not include net precipitation on the Lakes.

[d] Does not include runoff from upstream regions.

[e] Does not include runoff from Mexico.

[f] Virgin flow. Mean annual natural runoff estimated to be 13.7 bgd.

[g] Rounded.

[h] Not available.

[i] Using 95% figures.

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[41] pp. 3-2-6.

The most promising source of water for dust control, pipeline slurry media and coal cleaning operations appears to be underground water. Figure 31 shows major areas of potential groundwater development. The alluvial basins in the arid far West are the most promising developmental areas because they are surrounded by mountains from which they receive runoff replenishment. Rich coal bearing regions in New Mexico, Colorado and Utah are included in the alluvium filled valleys. Portions of Montana and North Dakota are underlain for hundreds of miles by water abundant rock. This partly explains the increased interest in North Dakota as a major source of gas-from-coal plants which require enormous quantities of water. Wyoming appears to have less water potential than the other states included in this study. An example of large-scale use of underground water for coal related processes is the Black Mesa pipeline in Arizona. A supply of 2000 gpm was determined to be needed to transport coal from the mine to the power plant 273 miles away.[44] Wells to a depth of 3800 feet supply the water from Navajo sandstone. The estimate of water in this one location is about 10,000,000 acre-feet. The 35-year life of the pipeline may require that upwards of 100,000 acre-feet be withdrawn, leaving 99% of the original water in the ground.

Water supply in the West is not without substantial problems. Table 25 shows existing and emerging water management problems for various regions of . U.S. Besides inadequacy of runoff water and ground water shortage depletion in nonalluvial basins, increasing salinity of water and sedimen-

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[44] Anon. The Black Mesa Plan: Energy Today, Better Land Tomorrow. Coal Age. 78:82, March 1971.

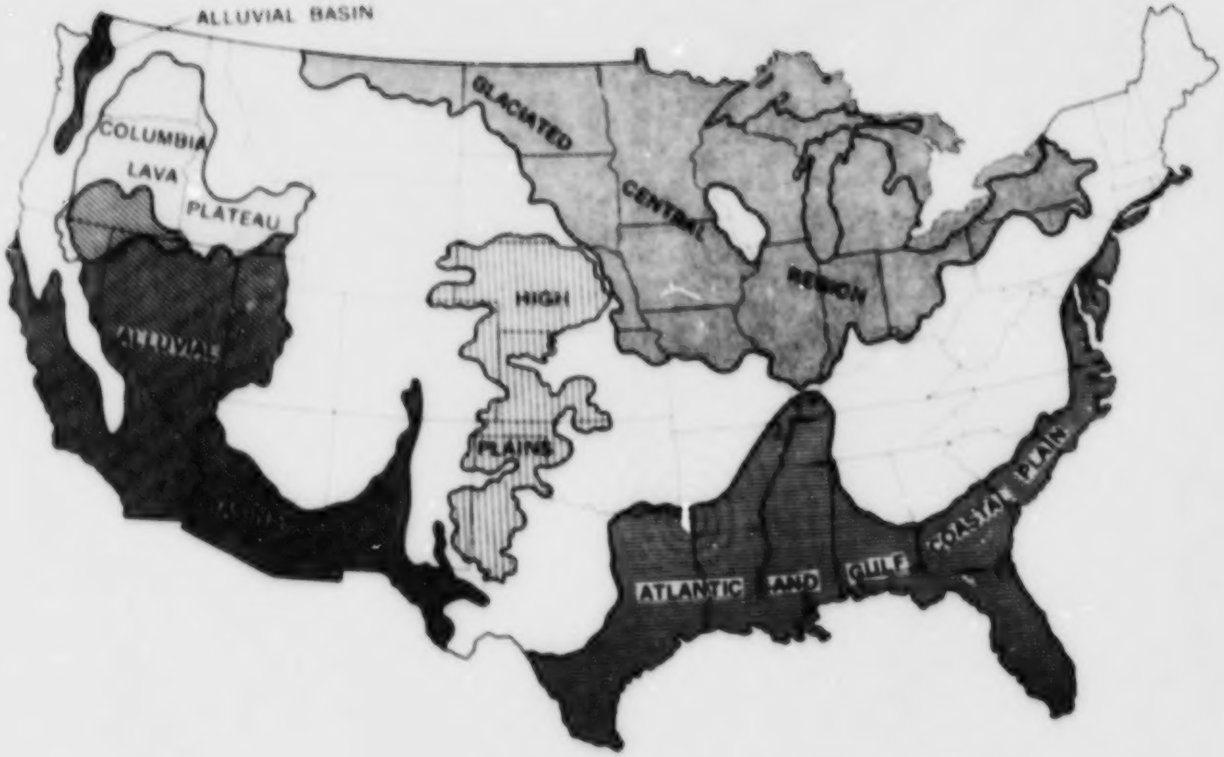
ALLUVIAL BASIN
COLUMBIA
LAVA
PLATEAU
GLACIATED
CENTRAL
REGION
HIGH
PLAINS
ALLUVIAL
ATLANTIC
AND
GULF
COASTAL
PLAIN

Figure 31. Major areas of potential ground water development[41]

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[41] p. 3-2-8.

Table 25. EXISTING AND EMERGING WATER MANAGEMENT PROBLEMS IN THE UNITED STATES*[1]

Region	Adequacy of annual natural runoff	Ground-water storage depletion	Water Quality				Flood damages	Watershed lands	Beach, shore, and riverbank erosion	Wetlands
			Wastes	Heat	Salinity	Sediment				
North Atlantic	C	C	A	A	D	C	C	C	B	B
South Atlantic-Gulf	D	C	B	C	D	B	B	B	A	A
Great Lakes	C	D	A	A	D	C	D	D	C	C
Ohio	C	D	B	B	D	C	B	C	D	D
Tennessee	D	D	C	C	D	C	C	C	D	D
Upper Mississippi	C	D	B	B	D	C	B	C	B	B
Lower Mississippi	D	D	C	D	D	A	B	B	B	B
Souris-Red-Rainy	B	D	C	D	C	D	B	D	C	B
Missouri	B	B	C	C	C	B	A	B	B	B
Arkansas-White-Red	B	A	C	D	A	B	B	B	A	B
Texas-Gulf	B	A	B	C	B	B	C	B	B	B
Rio Grande	A	A	B	D	A	A	C	B	C	D
Upper Colorado	A	D	C	D	C	B	D	C	D	D
Lower Colorado	A	A	B	D	A	A	C	B	C	D
Great Basin	A	C	B	D	C	C	D	C	D	C
Columbia-North Pacific	C	C	C	B	D	D	B	C	C	B
California	B	B	B	C	D	C	B	B	B	C
Alaska	D	D	C	D	D	D	C	D	B	C
Hawaii	D	C	C	D	D	D	D	C	B	[illegible]
Puerto Rico	D	D	C	D	D	B	D	B	C	D

A - Severe problem in some areas or major problem in many areas.

B - Major problem in some areas or moderate problem in many areas.

C - Moderate problem in some areas or minor problem in many areas.

D - Minor problem in some areas.

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*[1] Pp. 1-23.

tation appear to limit industrial activity to selected regions which may not correlate with the vast deposits of western coal. Added to these problems is the fact that the coal deposits themselves may form a portion of the aquifer system. The effect of water shortages, unless countermeasures are taken, will be an adjustment in the pattern of economic activity. An increase in the use of saline water in the West is expected as more readily available supplies of fresh water are depleted. Contamination of this sort can be minimized by the increased use of underground water. Resource management of all sources of water will ensure the continued success of western coal mining. Consequently, water supply in the West does not appear to be a limiting factor in supplying coal to midwestern and interior province states.

A more detailed investigation of future water availability is beyond the scope of this report. One currently ongoing western water resource investigation that promises the development of a general plan to meet the future water needs of eleven western states is the Westwide Water Study (WWS) undertaken by the Department of the Interior.[45] The area of the study encompasses eight of the ten important coal bearing states in this report; namely, Arizona, Colorado, Montana, New Mexico, Oregon, Utah, Washington, and Wyoming. The WWS is a full and complete reconnaissance to develop the general plan. The objectives of this study, which was started in 1968 and will be completed by June 1977, are as follows: (1) to project the West of the future with regard to population, industry, agriculture, environment and social makeup; (2) to determine water supply from all available sources; (3)

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[45] Fairchild, W. D. The Westwide Water Study. J. Amer. Water Works Ass. 63:706-710, November 1971.

to translate projected future conditions into water requirements and balance them against available and potential water supplies; and (4) to develop a general plan to meet these needs and in optimum manner. The Colorado River will be studied to determine the most economically acceptable means of augmenting its supply. Importation of water from natural river drainage areas located in other than the Colorado River Basin states is excluded.

Potential sources for the development of new water supplies include weather modification, desalination of seawater and brackish water, geothermal development, and waste water reclamation. Preliminary studies indicate that an additional annual runoff of up to 1.8 million acre-feet could be produced by winter cloud seeding in the Colorado River Basin alone.[45] Production costs for this augmentation are estimated at $1.00-1.50/acre-ft. Desalting existing water supplies promises to be a potential source of augmentation if done on a large scale and if plant brine effluents can be disposed of safely. It is estimated that 2.5 million acre-ft/yr of new water could be produced for 100 years from geothermal wells. Water would have to be recovered from geothermal brines by desalting. The WWS forecasts geothermal wells coupled with power plants and desalting units if the study advances to the point where a reliable estimate of this potential water supply can be predicted. The WWS has begun to inventory waste water sources and the prospects for their utilization. One use for treated waste water is crop irrigation which consumes a major amount of water. Considerable attention has been given to the total reclamation and reuse of domestic and industrial waste water as a supplement to present water supplies.

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[45] p. 708.

3.5 WESTERN COAL COMPOSITION AND ASSORTED PHYSICAL AND CHEMICAL PROPERTIES

Western coals possess properties characteristically different from eastern coals. Besides being inherently low in sulfur, they are generally more prone to fouling and have lower calorific value per pound. A large majority of the coal mined in the West is of the subbituminous and lignitic ranks and is surface mined. The ASTM ranking classifications are given in Table 26 which shows that subbituminous coals have a Btu per pound range from 8300 to 11,500 on a moist, mineral matter-free basis. Lignite ranges from below 6300 to 8300 Btu per pound. Figure 32 is a graphical representation of all coals and indicates that subbituminous coals have lower fixed carbon and higher inherent moisture than higher ranking bituminous and anthracite coals.

Statewide values for coal composition, heating value, ash softening temperature, rank index and ash analyses are presented here. Additional combustion process related properties such as Hardgrove grindability index and total carbon loss may be found in Section 4 of this report. This section also relates these coal properties to combustion behavior. Detailed coal analysis data compiled for individual mines and coalfields are reported in Appendix G.

Table 27 shows representative minimum, maximum and average values of coal characteristics for 20 states including eight western states. Rank index is included and is defined as:

$$\text{RI} = \text{Rank Index} = \frac{\text{Btu (dry basis)}}{\text{Volatile matter (dry basis)} \times 10} \qquad (1)$$

Table 26. CLASSIFICATION OF COALS BY RANK[a],46

Class	Group	Fixed Carbon Limits, % (Dry, Mineral-Matter-Free Basis)		Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis)		Calorific Value Limits, Btu per pound (Moist,[b] Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	
I. Anthracitic	1. Meta-anthracite	98	--	--	2	--	--	Nonagglomerating
	2. Anthracite	92	98	2	8	--	--	
	3. Semianthracite[c]	86	92	8	14	--	--	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	--	--	Commonly agglomerating[e]
	2. Medium volatile bituminous coal	69	78	22	31	--	--	
	3. High volatile A bituminous coal	--	69	31	--	14,000[d]	--	
	4. High volatile B bituminous coal	--	--	--	--	13,000[d]	14,000	
	5. High volatile C bituminous coal	--	--	--	--	11,500 10,500[e]	13,000 11,500	Agglomerating
III. Subbituminous	1. Subbituminous A coal	--	--	--	--	10,500	11,500	Nonagglomerating
	2. Subbituminous B coal	--	--	--	--	9,500	10,500	
	3. Subbituminous C coal	--	--	--	--	8,300	9,500	
IV. Lignitic	1. Lignite A	--	--	--	--	6,300	8,300	
	2. Lignite B	--	--	--	--	--	6,300	

[a] This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48% dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free British thermal units per pound.

[b] Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[c] If agglomerating, classify in low-volatile group of the bituminous class.

[d] Coals having 69% or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[e] It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high volatile C bituminous group.

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[46] [illegible] New York, [illegible] Company, [illegible] pp. 5-11.

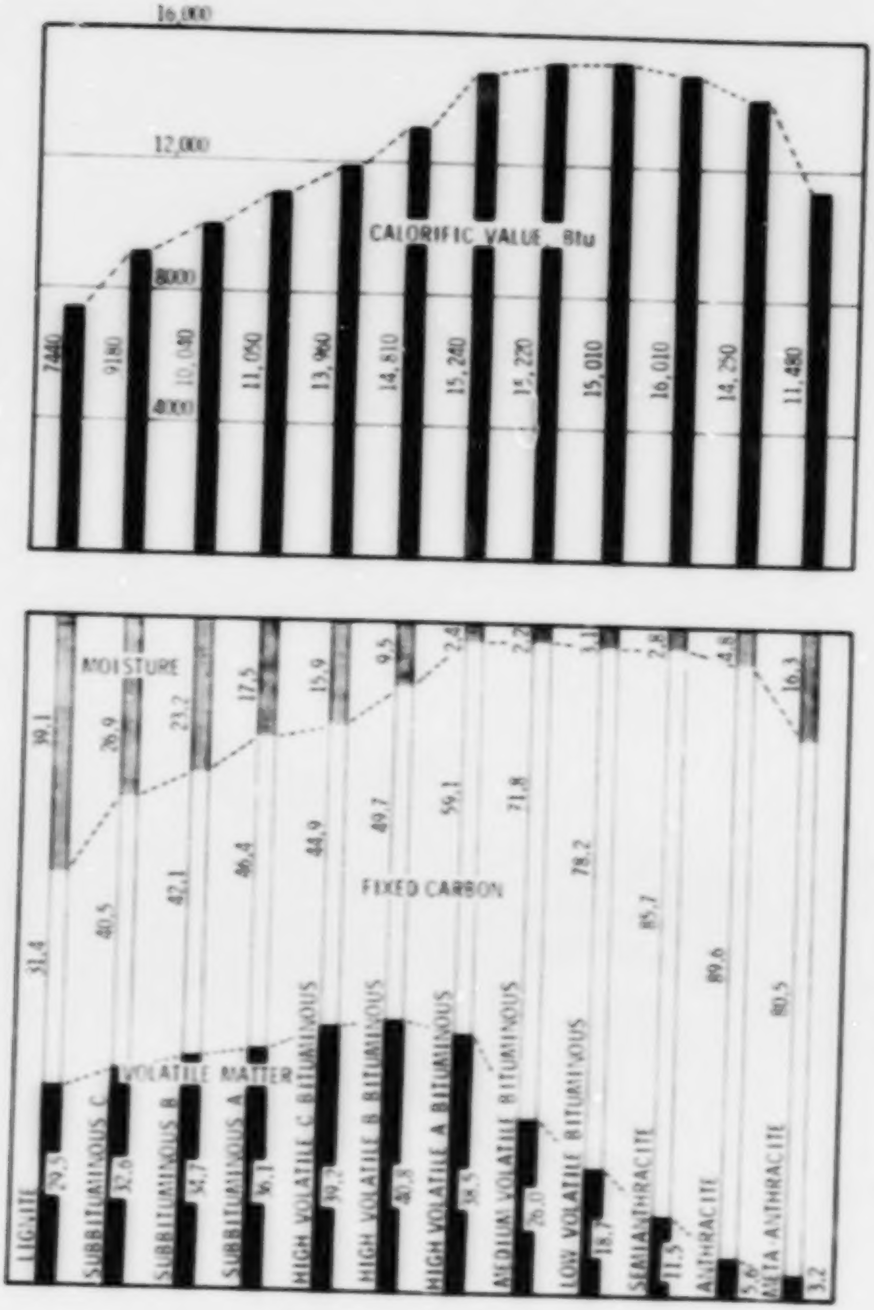

Figure 32. Analysis of United States coals selected to represent the various ranks[13]

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[13] p. 32.

Table 27. RANGE OF COAL CHARACTERISTICS[47],[48]

State		Moisture	Volatile Matter	Fixed Carbon	Ash	S	H	C	N	O	Btu	Ash Softening Temperature	Rank Index
Alabama	Min.	2.3	29.7	51.3	2.5	0.6	--	--	--	--	12160	2130	33.0
	Ave.	4.7	37.7	55.9	6.1	1.2	4.9	76.9	1.8	8.7	13280	2320	38.3
	Max.	17.4	42.0	62.7	14.6	2.0	--	--	--	--	14150	2600	45.7
Arizona	Ave.	11.7	44.4	47.1	8.5	0.4	5.1	73.3	1.1	14.6	10800	--	24.5
Colorado	Min.	4.6	37.2	40.6	5.1	0.3	--	--	--	--	10730	2240	24.7
	Ave.	12.5	39.6	51.8	8.6	0.6	--	--	--	--	11650	--	27.4
	Max.	22.7	43.3	55.1	19.6	1.1	--	--	--	--	12270	2910+	32.2
Illinois	Min.	4.9	35.3	44.5	6.1	1.5	--	--	--	--	10050	2000	24.5
	Ave.	11.5	41.0	49.1	9.1	2.8	--	--	--	--	11791	2090	28.9
	Max.	21.3	47.4	53.7	11.5	4.1	--	--	--	--	12910	2181	35.1
Indiana	Min.	8.8	38.1	44.4	7.7	1.1	--	--	--	--	10670	2000	24.8
	Ave.	11.4	42.7	47.5	9.8	3.0	--	--	--	--	11540	2190	26.9
	Max.	19.3	45.3	52.4	11.6	4.0	--	--	--	--	12370	2700	31.0
Iowa	Min.	4.4	38.1	32.1	13.1	2.5	4.0	52.6	0.8	4.1	8950	1920	22.5
	Ave.	17.4	42.3	42.0	18.1	4.5	4.5	62.0	1.3	6.6	9580	2060	23.7
	Max.	19.3	49.1	46.6	29.4	10.0	4.9	68.7	1.6	9.9	10970	2155	24.9
Kansas	Min.	5.5	35.6	47.3	8.5	2.1	4.9	70.0	--	3.1	8950	1980	30.7
	Ave.	4.6	38.5	51.5	11.0	3.8	5.0	72.4	1.2	7.7	9580	2020	33.2
	Max.	7.8	40.8	55.0	11.3	4.4	5.1	73.3	--	9.1	10970	2070	35.5
Kentucky	Min.	2.7	31.6	45.2	3.6	0.6	5.3	--	--	--	11215	2130	27.7
	Ave.	5.3	39.0	53.3	7.8	2.7	5.4	79.5	1.6	7.2	12850	2415	31.8
	Max.	19.9	47.1	60.7	17.7	3.9	5.5	--	--	--	14155	2800	42.3
Missouri	Min.	[illegible]	43.7	46.7	6.6	--	--	--	--	--	11390	2020	25.7
	Ave.	[illegible]	44.5	47.1	8.4	4.1	--	--	--	--	11530	2030	26.2
	Max.	[illegible]	44.3	47.4	9.0	--	--	--	--	--	11680	2050	26.7
Montana	Min.	7.2	33.0	44.0	7.2	0.4	--	--	--	--	7290	2180	17.4
	Ave.	25.4	37.2	51.1	10.7	1.0	4.5	68.1	1.0	14.7	8680	2410	22.7
	Max.	[illegible]	42.3	58.5	18.0	2.3	--	--	--	--	11030	2590	33.4
New Mexico	Min.	11.7	44.1	45.3	7.1	--	--	--	--	--	--	2080	24.6
	Ave.	[illegible]	44.2	47.6	8.2	0.7	5.2	75.6	1.3	17.6	10790	--	25.4
	Max.	[illegible]	44.3	48.6	9.3	--	--	--	--	--	--	2910+	26.2
North Dakota	Min.	33.1	42.1	46.9	7.9	0.6	--	--	--	--	--	1920	15.2
	Ave.	37.1	42.3	48.1	9.6	0.7	--	--	--	--	6750	2240	16.9
	Max.	[illegible]	44.2	49.2	13.1	1.0	--	--	--	--	--	2520	18.2
Ohio	Min.	3.3	39.1	45.3	6.1	2.1	--	--	--	--	11940	--	27.1
	Ave.	7.4	41.8	48.7	9.4	2.7	5.1	74.5	1.5	6.2	12560	--	30.1
	Max.	9.2	45.1	54.1	15.4	3.2	--	--	--	--	13440	--	36.0
Oklahoma	Min.	[illegible]	35.4	47.9	7.1	--	--	--	--	--	12730	--	29.9
	Ave.	[illegible]	40.2	49.7	9.5	3.5	5.5	76.8	1.5	5.6	12970	--	31.1
	Max.	[illegible]	46.3	49.0	12.5	--	--	--	--	--	13420	--	32.1
Pennsylvania	Min.	1.3	16.0	46.3	5.8	0.7	4.9	73.7	1.0	4.9	10750	2025	30.9
	Ave.	3.7	33.6	57.0	9.4	2.1	5.1	78.7	1.4	5.6	13520	2415	45.7
	Max.	10.2	41.4	77.0	21.0	8.1	5.4	79.5	1.5	6.9	14420	2910+	68.9
Tennessee	Min.	1.9	29.2	51.4	10.0	0.4	--	--	--	--	12370	2080	35.1
	Ave.	3.3	32.0	55.1	12.7	1.0	4.9	73.5	1.8	7.2	12991	2460	40.0
	Max.	5.8	36.4	61.0	24.0	1.2	--	--	--	--	13350	2910+	46.0
Utah	Min.	2.4	35.4	44.4	5.7	0.3	--	--	--	--	11370	2130	26.8
	Ave.	7.1	45.2	47.1	7.3	0.5	--	--	--	--	11490	2250	28.7
	Max.	9.7	47.3	53.5	13.6	0.8	--	--	--	--	12950	2400	33.7
Washington	Min.	4.4	35.0	40.0	15.6	0.1	--	--	--	--	11630	2590	30.6
	Ave.	[illegible]	38.0	45.2	15.9	0.7	--	--	--	--	11670	--	30.7
	Max.	[illegible]	38.0	46.4	16.0	0.4	--	--	--	--	11720	2910+	30.8
West Virginia	Min.	1.3	29.1	53.0	2.6	0.6	4.3	73.1	1.2	1.9	11940	2070	33.1
	Ave.	1.6	35.4	56.7	7.9	1.0	5.1	80.0	1.5	5.3	13190	2540	38.0
	Max.	5.0	40.6	65.6	16.5	1.6	7.0	86.6	1.9	7.9	14390	2910+	49.9
Wyoming	Min.	20.6	41.7	47.1	3.5	0.5	--	--	--	--	9540	--	22.3
	Ave.	23.1	43.4	50.8	5.7	0.8	5.0	72.1	1.6	19.1	10140	2450	22.9
	Max.	25.9	46.4	54.2	7.9	1.0	--	--	--	--	10700	--	23.7

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[47] Anon. Analyses of Tipple and Delivered Samples of Coal. Bureau of Mines Rept. of Inv. 6086, 1962 (a), 6461, 1964 (b), 6622, 1965 (c), 6792, 1966 (d), 6904, 1967 (e), 7104, 1968 (f), 7219, 1969 (g), 7346, 1970 (h), 7490, 1971 (i), 7712, 1973 (j), and 7848, 1973 (k).

[48] Snyder, N. H., and J. J. Aresco. Analyses of Tipple and Delivered Samples of Coal (Collected During the Fiscal Years 1948 to 1950 Inclusive). Bureau of Mines Bulletin. 516. 1953. 111 p.

The importance of rank index values is explained in Section 4.

Moisture and Btu values given are "as received." All other properties are on a dry basis. Averages are arithmetic estimates of available data. Coal rank as a function of Btu content can be found in Table 26. Oxygen percentage is also a general indication of rank since it is usually true that rank goes down as oxygen percentage increases. In Table 26, compositions are reported in weight percent, calorific values in Btu per pound and ash softening temperatures in degrees Fahrenheit.

Ash analyses reported as oxides are shown in Table 28. Averages were computed as non-weighted arithmetic means.

Trace elements typically found in U.S. Coal ash from all regions are barium, beryllium, boron, cadmium, chromium, cobalt, copper, fluoride, gallium, germanium, lanthanum, lead, lithium, manganese, mercury, molybdenum, nickel, scandium, selenium, strontium, tin, vanadium, ytterbium, zinc and zirconium.[50] Also present on a less widespread basis are arsenic, bismuth, cerium, neodymium, niobium (columbium), rubidium and thallium.

Trace element contents in coal ash for three areas of the U.S. are shown in Table 29 and the majority of these plotted in Figure 33 along with crustal abundance of the elements. With few exceptions, trace elements are more abundant in coal than they are in the earth's crust or soil. When compared

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[50] Abernethy, R. F., M. J. Peterson, and F. H. Gibson, Spectrochemical Analyses of Coal Ash for Trace Elements. Bureau of Mines Report of Investigations. 7281. 1969. p. 1.

Table 28. TYPICAL ASH COMPOSITION[a,49]
(Wt.-%)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	[illegible]	[illegible]	Na_2O	K_2O	SO_3
[illegible]													
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]													
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Ave.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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[a] [illegible]

[b] [illegible]

Table [illegible]. AVERAGE TRACE ELEMENT CONTENT IN ASH OF COAL FROM THREE AREAS, AS WEIGHT PERCENT[a], [50]

Element	Crustal abundance[b]	Approximate lower limit of detection[c]	Eastern Province		Interior Province		Western States	
			Frequency of detection	Average trace element content of ash	Frequency of detection	Average trace element content of ash	Frequency of detection	Average trace element content of ash
Barium	0.0425	0.002	100	0.0876	100	0.0399	100	0.1461
Beryllium	.00028	.0001	100	.0012	100	.0014	100	[illegible]
Boron	.0010	.0002	100	.0265	100	.0741	100	[illegible]
Chromium	.0100	[illegible]	100	.0230	100	.0224	100	.0066
Cobalt	.0025	.0020	100	.0184	98	.0193	98	.0097
Copper	.0055	.0001	100	.0128	100	.0085	100	.0147
Gallium	.0015	.0002	100	.0071	100	.0085	100	.0031
Germanium	.00015	.0003	99	.0048	100	.0104	91	.0017
Lanthanum	.0030	.01	92	.0140	86	.0131	81	.0104
Lead	.0013	.0001	100	.0065	100	.0131	100	.0079
Lithium	.0020	.0001	100	.0584	100	.0035	100	.0148
Manganese	.0950	.0001	100	.0260	100	[illegible]	100	.0212
Molybdenum	.00015	.0001	99	.0082	99	.0071	100	.0020
Nickel	.0075	.0001	100	.0209	100	.0262	100	.0054
Scandium	.0022	.002	100	.0046	100	.0064	97	.0012
Strontium	.0375	.001	100	.1052	100	.0458	100	.1408
Tin	.0002	.0001	100	.0019	99	.0019	100	.0027
Vanadium	.0135	.0001	100	.0336	100	.0275	100	.0152
Ytterbium	.00034	.0001	100	.0007	100	.0006	100	.0006
Yttrium	.0033	.001	100	.0148	100	.0118	100	.0096
Zinc	.0070	.005	98	.0230	100	.0743	91	.0258
Zirconium	.0165	.005	100	.0734	100	.0825	100	.0807
Arsenic	.00018	.005	67	.0159 (.0107)	41	.0119 (.0049)	18	.0071 (.0013)
Bismuth	.00002	.0001	82	.0002 (.00022)	77	.0071 (.00055)	[illegible]	.0001 (.0001)
Cerium	.0060	.02	31	.0238 (.0074)	11	.0224 (.0024)	19	.0210 (.0011)
Neodymium	.0028	.01	29	.0219 (.0062)	15	.0184 (.0027)	15	.0295 (.0044)
Niobium (columbium)	.0020	.001	73	.0053 (.0039)	58	.0086 (.0048)	81	[illegible] ([illegible])
Rubidium	.0090	.001	97	.0249 (.0242)	100	.0275 (.0275)	18	.0041 (.0010)
Thallium	.00005	.0005	43	.0021 (.0009)	45	.0109 (.0004)	1	.0001 (.00001)
Average Trace Element, % of Ash				.665		.6449		.6441
Average Ash, % of Dry Coal				9.3		15.5		9.8
Average Trace Element, % of Dry Coal				.0619		.0695		.0616
Number of Samples				605		171		104

[a] Averages calculated for number of samples in which element was detected, except that averages in parentheses were calculated for all of the samples tested using zero for element contents below limit of detection.

[b] Mason, Brian. Principles of Geochemistry. John Wiley & Sons, Inc., New York, 3d ed., 1966, pp. 45-46.

[c] Peterson, M. J., and J. B. Zink. A Semiquantitative Spectrochemical Method for Analysis of Coal Ash. BuMines Report of Inv. 6496, 1964, pp. 8-10.

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[50] p. 4 (modified).

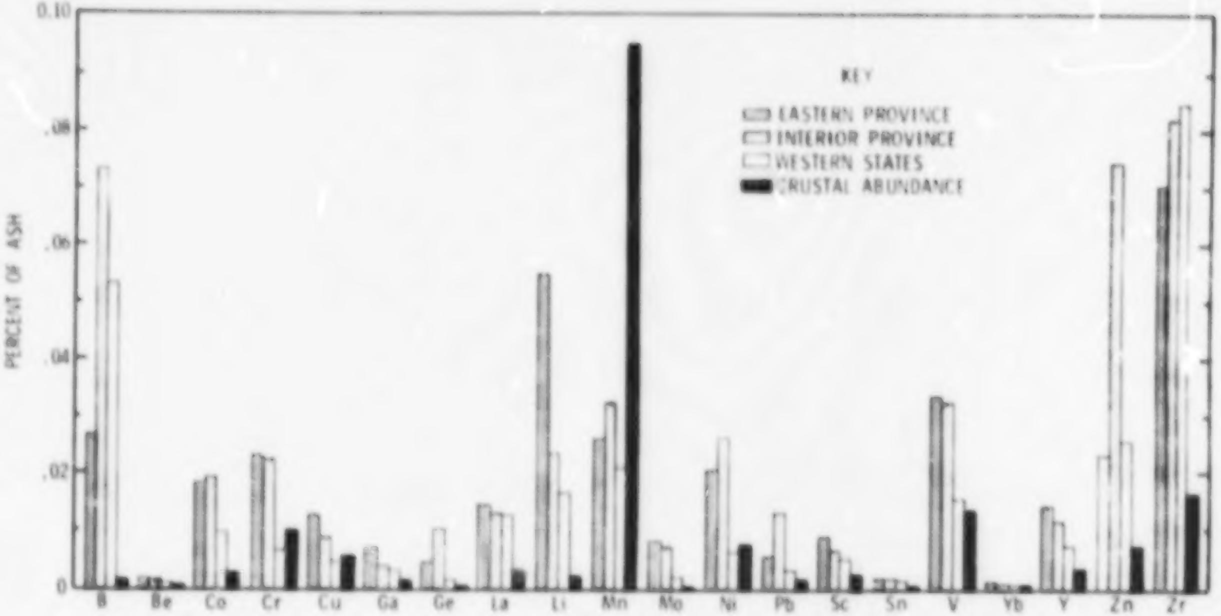

Figure 35. Average trace element content in ash of coal from three areas compared with crustal abundance[a,50]

[a] Barium and strontium not included

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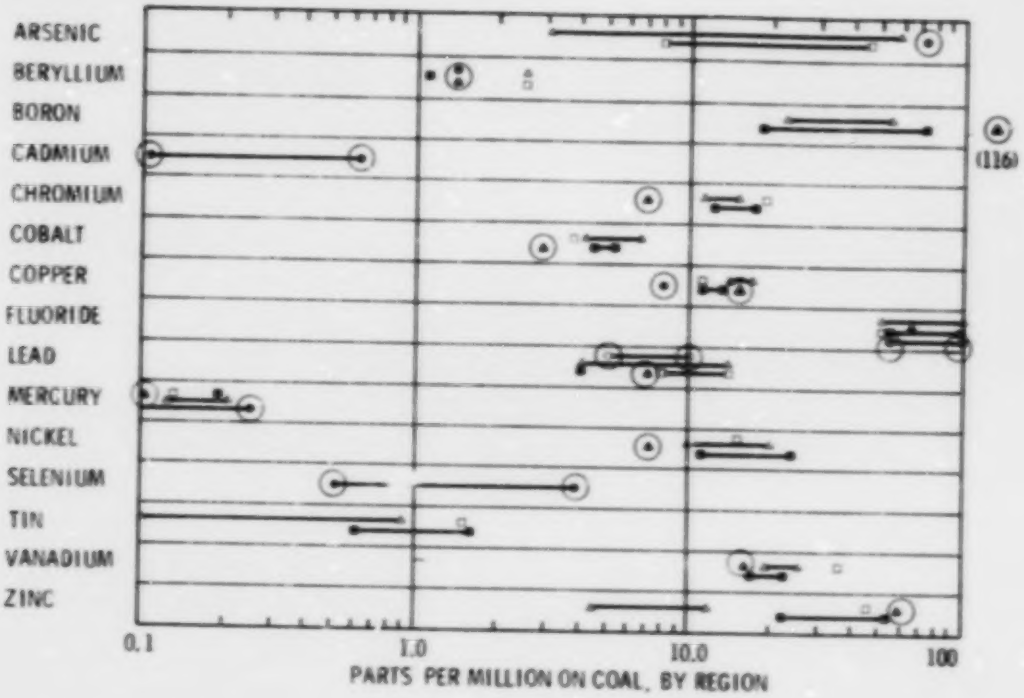
[50] p. 5.

to eastern and interior province coals, it appears that western coals contain similar amounts of total trace elements in ash and in dry coal. Figure 34 shows par-per-million levels in coal of some trace elements not listed in Table 29, notably cadmium, mercury and selenium. Values obtained are circled for western states. These elements would not normally be detected in ash samples due to their higher volatility.

Although total trace element content in western coal ash (0.6466%) is nearly equivalent to interior and eastern province coal ash contents (0.6568% and 0.6651%, respectively), the distribution of each element is notably different. Examination of Table 29 shows western barium, strontium and zirconium levels greater than those in eastern or interior province coals. All other elements in Table 29 either are of considerably lower levels or are unchanged for western coals. Figure 34 shows the presence of cadmium and selenium indigenous only to western coals, with mercury levels comparable for all U.S. coals.

Table 30 presents trace element ash averages of western coal for eight of the ten states included in this study. Washington coal ash samples had the largest quantity of trace elements. It is difficult to extend these results to all coals in a particular state because of the limited number of samples tested (104). We have tried to investigate whether the total trace element content in coals follows some recognizable trends. Figure 35 is a plot of total trace element content in coal against ash content of coal based on data from Table 30. First, no correlation seems to exist relating ash percent in coal to trace element content. Second, if the states are ranked from north to south, it



SYMBOL	REGION	STATES INCLUDED
△	APPALACHIAN (A)	PENNSYLVANIA, OHIO WEST VIRGINIA, MARYLAND VIRGINIA, EASTERN KENTUCKY, TENNESSEE, ALABAMA, (AND GEORGIA)
□	INTERIOR-EASTERN (IE)	ILLINOIS, INDIANA, WESTERN KENTUCKY, MICHIGAN
■	INTERIOR-WESTERN (IW)	IOWA, MISSOURI, NEBRASKA, KANSAS, OKLAHOMA, ARKANSAS, TEXAS
○	WESTERN (W)	WYOMING, IDAHO, UTAH, COLORADO, NEW MEXICO, ARIZONA, WASHINGTON
●	SOUTHWESTERN (SW)	UTAH, COLORADO, ARIZONA, NEW MEXICO
▲	NORTHERN GREAT PLAINS (N)	MONTANA, NORTH DAKOTA, SOUTH DAKOTA

Figure 34. Trace element concentrations in coal[51]

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[51] Cowherd, C., and J. L. Spigarelli. Hazardous Emission Characterization of Utility Boilers - Prelimiary Test Plan. Midwest Research Institute. Kansas City, Missouri. August 1974. p. 7.

Table 30. AVERAGE TRACE ELEMENT CONTENT IN ASH OF COALS FROM WESTERN STATES, PERCENT OF ASH[50]

Element	Arizona	Colorado	Montana	New Mexico	North Dakota	Utah	Washington	Wyoming
Barium	0.0400	0.0791	0.3000	0.2250	0.2650	0.1122	0.1714	0.1947
Beryllium	.0010	.0006	.0012	.0008	.0002	.0001	.0004	.0008
Boron	.0507	.0494	.0475	.0451	.0337	.0043	.0314	.0417
Chromium	.0109	.0049	.0024	.0091	.0046	.0048	.0121	.0067
Cobalt	0	.0104	.0061	.0115	.0057	.0066	.0217	.0065
Copper	.0051	.0049	.0025	.0050	.0013	.0038	.0121	.0050
Gallium	.0050	.0032	.0039	.0034	.0020	.0030	.0059	.0017
Germanium	.0050	.0019	.0025	.0032	.0006	.0008	.0009	.0018
Lanthanum	0	.0129	.0097	.0150	.0096	.0101	.0111	.0053
Lead	.0040	.0031	.0038	.0040	.0022	.0024	.0025	.0007
Lithium	.0200	.0095	.0215	.0138	.0095	.0283	.0272	.0217
Manganese	.0100	.0216	[illegible]	.0165	.0900	.0157	.0121	.0160
Molybdenum	.0013	.0018	.0038	.0017	.0032	.0011	.0024	.0025
Nickel	.0050	.0051	.0026	.0069	.0014	.0051	.0114	.0047
Scandium	.0010	.0066	.0034	.0068	.0046	.0037	.0089	.0045
Strontium	.1000	.0979	.2612	.0800	.2612	.1457	.1071	.1187
Tin	.0010	.0024	.0009	.0016	.0013	.0013	.0009	.0017
Vanadium	.0100	.0125	.0097	.0013	.0094	.0117	.0429	.0147
Ytterbium	.0001	.0006	.0004	.0005	.0004	.0002	.0004	.0004
Yttrium	.0100	.0073	.0060	.0085	.0060	.0047	.0014	.0073
Zinc	.0100	.0367	.0327	.0164	.0253	.0109	.0141	.0025
Zirconium	.0400	.0473	.0612	.0914	.0662	.0461	.1296	.0440
Average Trace Element % of Ash	.3281	.4586	.5094	.5794	.7416	.5536	.8449	.5467
Average Ash % of Dry Coal	9.7	[illegible]	12.6	11.8	12.6	7.5	12.7	8.7
Average Trace Element % of Dry Coal	.0318	.0422	.1045	.0684	.089	.0407	.1027	.0474
Number of Samples	1	40	8	14	8	21	7	[illegible]

[50] p. 11.

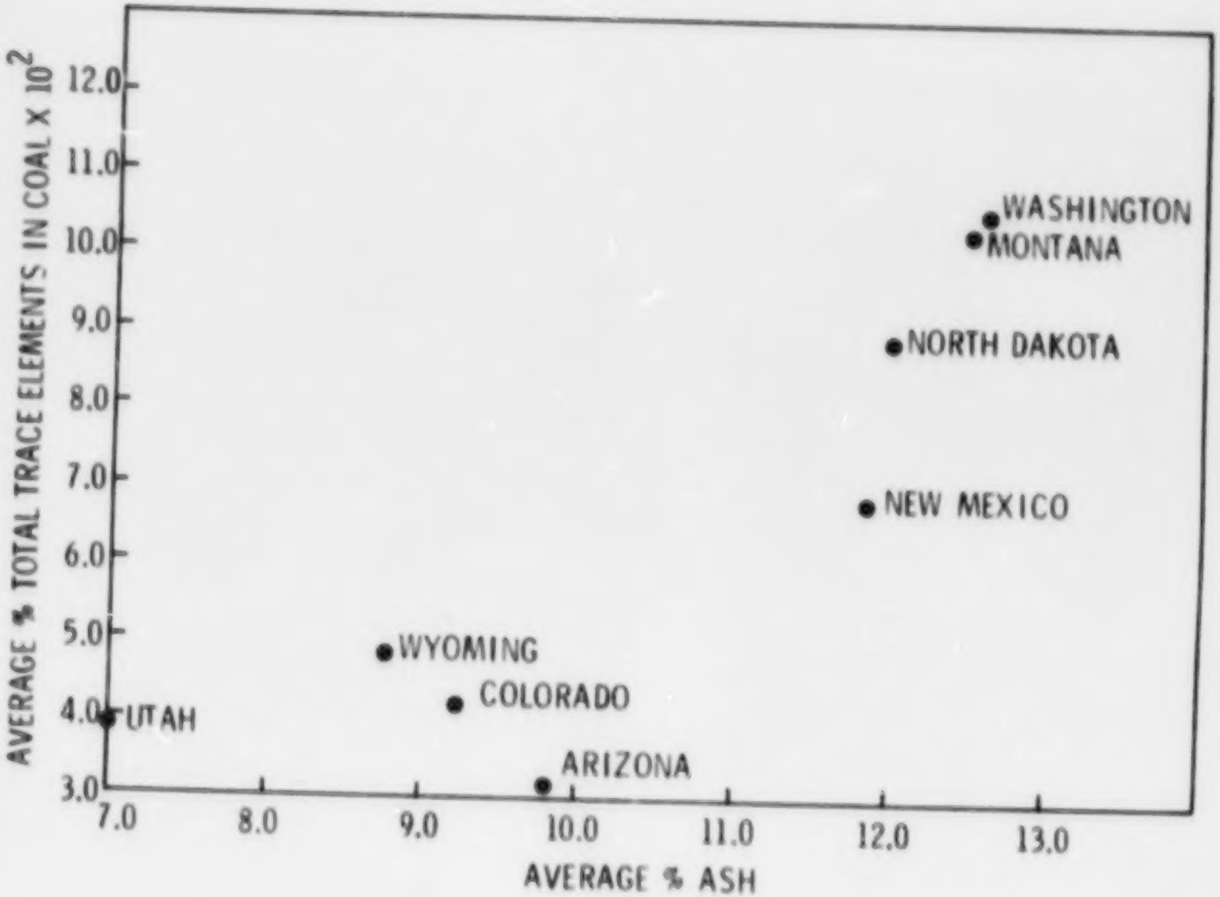

Figure 35. Trace elements vs coal ash content[a]

appears that trace element content generally increases in the northerly direction (Figure 36). Due to the variability of any type of coal data it appears impossible to completely verify these conclusions until more data are made available.

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[a] Data plot of Table 30.

Generally, a higher coal total sulfur content is accompanied by higher iron content. This is primarily due to iron and sulfur occuring in the form of pyrite, FeS_2. Additional significant conclusions and correlations relating to trace and minor elements in coal and coal ash made by Magee et al are reproduced below.[52]

1. The amount of sulfur in coal is moderate in the Appalachian region, higher in the interior region (east and west), and lower in all the western states.

2. Trace element concentration as a whole correlates only moderately with geographical location, and not at all with coal rank. Boron, which is high in lignites and lower in high rank coals, is an exception.

3. The amount of some trace elements is commonly highest in the top and bottom few inches of a bed, and at the edges of a coal basin (Ge, Be, Ga, and B at the bottom only). These variations are frequently greater than the differences between the averages for different beds. Other elements (Cu, Ni, Co) show no such correlation.

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[52] Magee, E. M., H. J. Hall, and G. H. Varga. Potential Pollutants in Fossil Fuels. Esso Research and Engineering Co. Linden, New Jersey, June 1973. pp. 70-72.

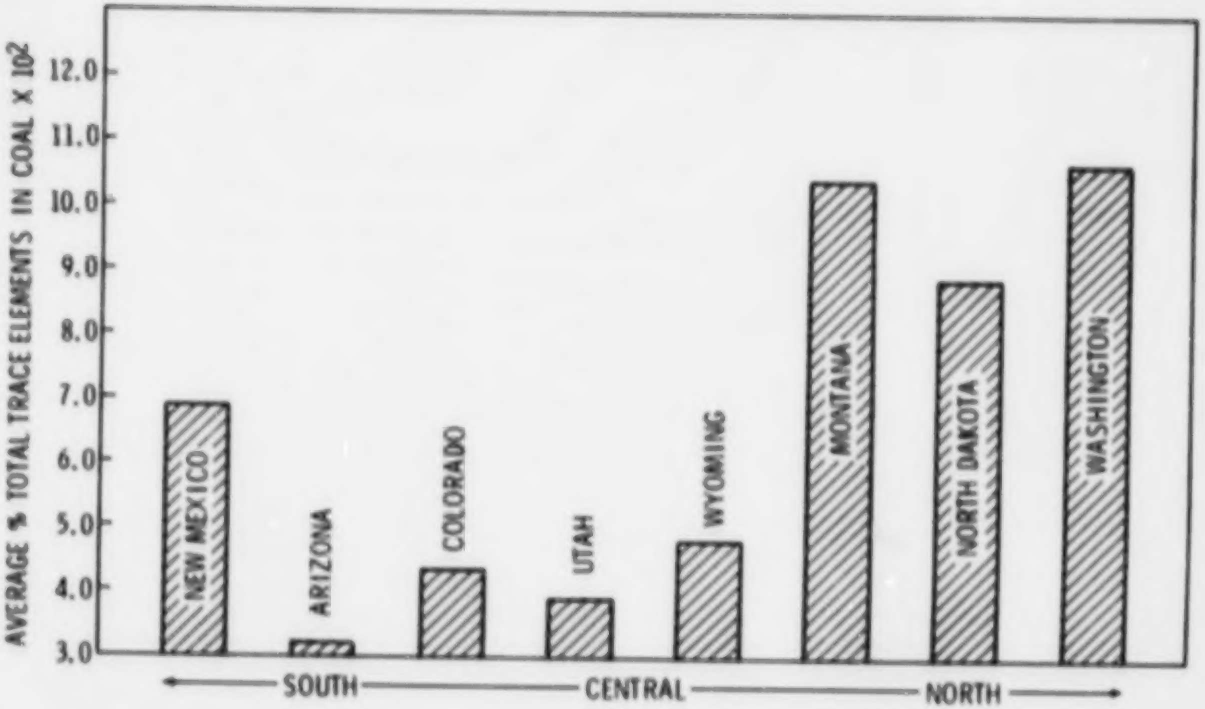

Figure 36. Regional trace element distribution[a]

[a] A plot of Table 30.

4. Different elements tend to be concentrated at different parts of a bed or basin, probably depending on the geochemical processes involved in the formation of the coal.

5. Those elements which tend to be concentrated in coals (S, Ge, Be, B, Ga) are associated primarily with the organic portion of the coal. They also show the largest variance in average concentrations between different major producing areas (germanium, e.g., is high in Illinois).

6. The usual amounts (concentrations) of some 20 trace elements present are about 5-10 ppm, in the (overall) range 1-50 ppm. B and F are higher, about 10-200 ppm, and Hg is lower, about 0.04-0.4 ppm.

7. Most trace elements are present in concentrations which fall within a narrow range, varying by a factor of 3 or less in the averages for different basins or areas. This range is close to their average crustal abundance, which usually lies between the concentration in ash. Boron and germanium in coal are high compared to crustal abundance, and only a few elements such as manganese are low.

8. The selection of a completely "non-polluting" coal is not possible, in the general case. For a given amount of ash, coals which are low in any one group of elements must be correspondingly high in others. The definition of non-polluting depends directly on the decision as to which elements are of concern and which are not.

9. Trace element variations between coals in different areas often reflect differences in the source rocks which contributed the elements to the coal-forming swamps, and the distance of the source rocks from the swamps. In certain areas, e.g., the Illinois basin, this shows an instructive geographical pattern.

10. Surface outcrops or samples weathered otherwise by exposure may not be indicative of trace element concentrations in the coal at depth. Surface oxidation creates active sites on the coal, with which minor elements in flowing water can selectively react.

11. The elements present in the largest amounts, as minor components of the coal rather than as traces only, are the common constituents of surface waters and rocks: silicon, aluminum, iron, sulfur, phosphorus, sodium, potassium, calcium, and magnesium. These are present throughout the coal but they are often enriched in the top layer, where they have apparently been leached out of enclosing sediments.

12. Anomalous amounts of specific elements may be found in beds contiguous to mineral ore bodies of the same element. This is regularly the case for coals having a mercury, lead, zinc or uranium content higher than the usual range, and may be equally true for other elements including copper, tin and arsenic.

3.6 TRANSPORTATION METHODS AND THE COST OF DELIVERED COALS

Western coal is moved to midwestern markets in a variety of ways. The lack of navigable waterways near the mine sites has spurred use of rail and other means of long range transport. The primary forms of transport are:

a) Rail
    1) integral trains
    2) unit trains
    3) common carriers

b) River and lake transport

c) Slurry pipeline and fixed tramways and conveyors

d) Truck

Since transportation costs can in some instances exceed one half the cost of producing coal, it is important to see where these costs originate and what characterized them. Figure 37 shows distance isopleths from Rocky Mountain coal areas to various consuming regions in steps of 500 miles.

Nearly 30% of the western coal produced in 1973 was shipped out of the coal producing regions (see Table 15). Essentially all of this coal was shipped by some form of rail transport. Small quantities were shipped via the Great Lakes and rivers. The major modes of transportation used to move coal throughout the western markets (70% of total production) were private railroad, truck, tramway, conveyor and slurry pipeline. A breakdown of western tonnage hauled by method of movement is given in Table 31. The 1973 haul basis (59.9 MMT) differs somewhat from the 1973 production figure (58.9 MMT) given in Table 15 because of combined methods of movement used in computing totals.

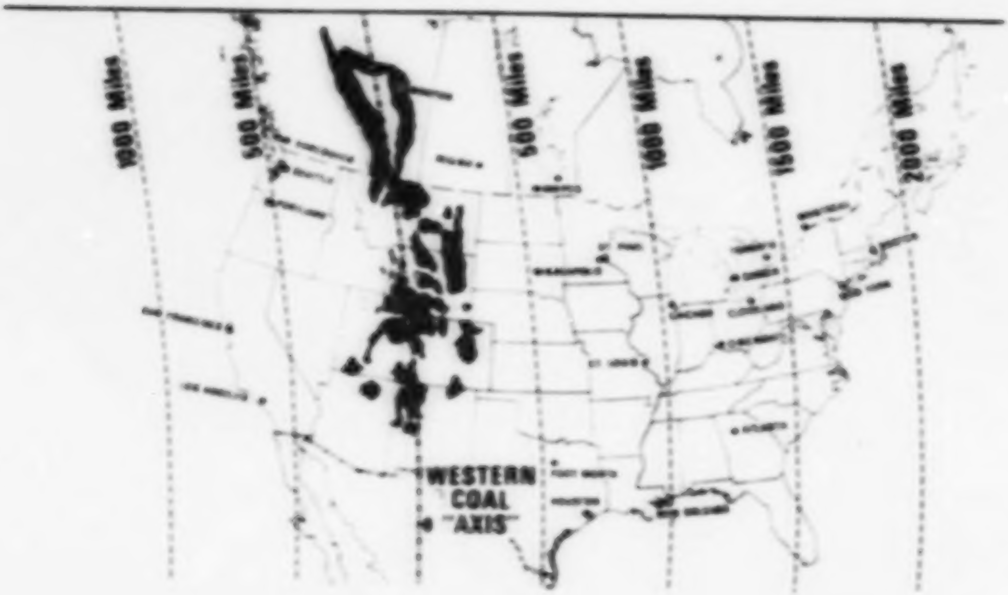
1000 Miles
500 Miles
500 Miles
1000 Miles
1500 Miles
2000 Miles
WESTERN
COAL
"AXIS"

Figure 37. Western coal distance to major markets[53]

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[53] Wasp, E. J., and T. L. Thompson. Bechtel Incorporated. Slurry Pipelines - Energy Movers of the Future. (Presented at the Interpipe 73 Conference. Houston, Texas. November 1, 1973.) p. 5.

Table 31. WESTERN COAL TONNAGE BY METHOD OF MOVEMENT[25]
(thousand tons)

Haul Basis for 1973 - 59.896 x 10⁶ Tons

Method of Movement	Western Use	Non-Western Use	Total
Rail	17924	15796	33720
% Total	29.9	26.4	56.3
River and Ex-River	0	681	681
% Total	0.0	1.2	1.1
Great Lakes	0	119	119
% Total	0.0	0.2	0.2
Truck	22130[a]	0	22130
% Total	36.9	0.0	36.9
Tramway, Conveyor, and Private Railroad	3246[a]	0	3246
% Total	5.4	0.0	5.4
Total Tonnage	43300	16596	59896
% of Total	72.2	27.8	100.0

[a] Some shipments via tramway, conveyor, slurry pipeline, and private railroad are included with the truck category.

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[25] pp. 1-41.

3.6.1 Rail Methods and Economics

Various rail methods are used to ship western coals to midwestern and other non-western locations. Major rail movements are usually made in complete trains handled as integral units. There are three types of movements involved. The first uses the "bulk rate" train or commercial carrier which is generally made up of shipments from one or more points or origin and requires a set minimum tonnage per train to qualify for special rates.[1] The "unit" train is made up for movement between one point of origin and one destination (with the possibility of alternating trips to other destinations to obtain better utilization of equipment).- The "integral" train consists of cars and motive power coupled from origin to destination and return (except possibly for periodic maintenance).[1]

Commercial or common carrier operation is characterized by individual coal car shipments dispatched from the regular railroad operating pool. Costs are high since cars are loaded or unloaded singly in small blocks as is done in normal rail shipments. In contrast, the unit train is used solely for the transport of coal to its market use. Delivery of sections of the unit train to various destinations proceeds enroute, and the cars are collected on the return trip. Variables that determine the best economic and technological balance of components are: minimum train tonnage, haul distance, car type, topographical conditions, capacity, quantity, motive power requirements, supply of railroad cars, loading facilities, unloading facilities, and storage.[1]

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[1] pp. 142, 142, 142, 142.

The integral train is even more specific in its functionality. This rail mode is entirely devoted to direct delivery of coal with no alternate deliveries enroute. Moves must be planned carefully, since the cars remain connected. The variables influencing the successful operation of the integral train are essentially those of unit trains. Both unit and integral trains are often referred to as shuttle trains.

Class 1 railroads that currently handle coal throughout the West and deliver to midwestern markets are listed in Table 32. Current freight prices for these rail systems are included where possible. Available cost data for rail transport from producing district to consumer state are given in Table 33. Figure 38 shows the major rail linkages between coal sources and existing and potential markets.

The existing rail system in the West is beset with a variety of technical problems that influence development and expansion. Rail expansions from the coalfields to midwest markets are faced with the problem of tremendously long dead head runs back to northwestern fields. One proposed solution to this problem is to haul non-toxic wastes westward from midwestern metro areas.[54]

The surface mined deep pits could be filled with the refuse which would help coal companies meet or exceed stringent near-original contour provisions of legislation. Cities would benefit from lessened waste disposal problems. Railroads might also realize a profit from the long haul back. All these concepts seem, however, far from realization and would require an enforcing legislation to be broadly accepted.

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[54] Blakely, J. W. The Western Scene. Coal Mining and Processing. 11:43, June 1974.

TABLE 48. SELECTED RAILROADS SERVING WESTERN COAL MARKETS AND POINTS EAST[1]
(Costs given are dollars per ton)

ATCHISON, TOPEKA AND SANTE FE RAILWAY CO.

Territory Served: Chicago and West, including Ill., Iowa (Ft. Madison), Mo., Kans., Colo., Okla., Tex., La., N.M., Ariz. and Calif.
1972 Coal Tonnage Moved: 3,751,213

BURLINGTON NORTHERN INC.

Territory Served: From Chicago, Ill., across the northern and central regions of the U.S. to Portland, Seattle, Vancouver, B.C., including states of Ill., Ind., Ky., Mo., Kans., Iowa, Wyo., Wis., Minn., N.D., S.D., Mont., Idaho, Wash., Ore., Calif., Neb., Colo., Manitoba and British Columbia
1972 Coal Tonnage Moved: 25,000,000 T.
Unit Train Tonnage: 15,000,000 T.
Percent of Total: 60.0%

Loading Point: Colstrip, Mont.
Cap.: 10,000 T.
Destination: Cohasset, Mn.
Time: [illegible] Days
Rate: $[illegible]

Loading Point: Colstrip, Mont.
Cap.: 6,600 T.
Destination: Minneapolis, Minn.
Time: 5 Days
Rate: $4.44

Loading Point: Colstrip, Mont.
Cap.: 10,000 T.
Destination: Plaines, Ill.
Time: 7 Days
Rate: $7.99

Loading Point: Zap, N.D.
Cap.: 4,000 T.
Destination: Glenharold, N.D.
Time: Daily
Rate: $.41

Loading Point: Colstrip, Mont.
Cap.: 5,000 T.
Destination: St. Paul, Minn.
Time: 5 days
Rate: $4.69

Loading Point: Colstrip, Mont.
Cap.: 10,000 T.
Destination: Hammond, Ind.
Time: 7 Days
Rate: $8.60

Loading Point: Colstrip, Mont.
Cap.: 10,000 T.
Destination: Havana, Ill.
Time: 7 Days
Rate: $ 7.22

Loading Point: Colstrip, Mont.
Cap.: 2,000 T.
Destination: Billings, Mont.
Time: 2 Days
Rate: $1.56

Loading Point: Decker, Mont.
Cap.: 10,000 T.
Destination: Havana, Ill.
Time: 5 days
Rate: $7.95

Loading Point: Kleenburn, Wyo.
Cap.: [illegible] T.
Destination: Havana, Ill.
Time: 7 Days
Rate: $7.88

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[1] pp. 157-161.

Table 32 (continued). CLASS I RAILROADS SERVING WESTERN COAL MARKETS AND POINTS EAST[1]
(costs given are dollars per ton)

CHICAGO AND NORTHWESTERN TRANSPORTATION CO.

Territory Served: Ill., Wis., Minn., Iowa, Mo., Neb., Wyo., N.D., S.D., Major gateways served: Chicago, E. St. Louis, Kansas City, Omaha, Fremont, Sioux City, Minneapolis, St. Paul, Duluth-Superior, Milwaukee
1972 Coal Tonnage Moved: 11,858,869 T.
Unit Train Tonnage: 7,976,739 T.
Percent of Total: 67.3%

Loading Point: Dana, Wyo.
Cap.: 90 Cars, 9,000 T. Min.; 100 car Max.
Destination: Waukegan, Ill.
Time: 5 Day Cycle
Rate: $6.08

Loading Point: Hanna, Wyo.
Cap.: 9,500 T. Min.
Destination: Sergeant Bluff, Iowa
Time: 3 Day Cycle
Rate: $2.63

Loading Point: Dana, Wyo.
Cap.: 90 Cars, 9,000 T. Min.; 100 car Max.
Destination: Hammond, Ind.
Time: 5-1/2 Day Cycle
Rate: $7.07

CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD CO.

Territory Served: Operates in the States of Ill., Iowa, Minn., Neb., Kans., Mo., Okla., Ark., Tex., La., N.M. and Colo.
1972 Coal Tonnage Moved: 2,160,356 T.
Unit Train Tonnage: None. Volume Rates.

DENVER AND RIO GRANDE WESTERN RAILROAD

Territory Served: Colorado and Utah
1972 Coal Tonnage Moved: 8,677,904 T.
Unit Train Tonnage: 5,365,088
Percent of Total: 61.8%
Unit Train Shipments:

Loading Point: Sunnyside, Utah
Cap.: 8,400 T.
Destination: Kaiser, Calif.
Time: 4 Days R.T.
Rate: $5.46

Loading Point: Somerset, Colo.
Cap.: 3,100-4,500 T.
Destination: Wash., Utah
Time: 12 Hrs. OW
Rate: $1.83

Loading Point: Carbondale, Colo.
Cap.: 3,200-6,000 T.
Destination: Geneva, Utah
Time: 12 Hrs. OW
Rate: $2.75

Loading Point: Carbondale, Colo.
Cap.: 6,400 T.
Destination: Kaiser, Calif.
Time: 4 Days R.T.
Rate: $6.86

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[1] pp. 157-161.

Table 32 (continued). CLASS I RAILROADS SERVING WESTERN COAL MARKETS AND POINTS EAST[1]
(costs given are dollars per ton)

Loading Point: Columbia, Utah
Cap.: 3,100-4,500 T.
Destination: Wash., Utah
Time: 10 Hrs. OW
Rate: $7.35

Loading Point: Wash., Utah
Cap.: 2,600-3,700 T.
Destination: Geneva, Utah
Time: 4 Hrs. OW
Rate: $1.21

Loading Point: Price, Utah
Cap.: 2,500 T.
Destination: Gadsby, Utah
Time: 2 Days R.T.
Rate: $2.40

ELGIN, JOLIET AND EASTERN RAILWAY CO.

Territory Served: Circle Chicago outside of Switching District beginning at Waukegan, Ill., on Lake Michigan on the North and swinging through Joliet, Ill., into Gary, Ind., and South Chicago, Ill., on Lake Michigan on the South.
1972 Coal Tonnage Moved: 10,282,460 T.
Unit Train Tonnage: 9,281,083 T.
Percent of Total: 90.3%

Loading Point: Colstrip, Mont.
Cap.: 10,000 T. Min.
Destination: Hammond, Ind.
Time: 7 Days
Rate: $8.03

Loading Point: Dana, Wyo.
Cap.: 9,000 T. Min.
Destination: Hammond, Ind.
Rate: $7.07

MISSOURI PACIFIC LINES

Territory Served: Midwest, South West and Western United States
1972 Coal Tonnage Moved: 8,945,879 T.
Unit Train Tonnage: 6,082,640 T.
Percent of Total: 68%

NORTHWESTERN PACIFIC RAILROAD

65 Market St., San Francisco, Cal. 95105
D. K. McNear, Pres.

SOO LINE RAILROAD

Territory Served: N.D., S.D., Minn., Wis., Upper Penin. Mich., Northwestern Ill. and Eastern Mont.
1972 Coal Tonnage Moved: 842,610 T.
Unit Train Tonnage: None

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[1] pp. 157-161.

Table 32 (continued). CLASS I RAILROADS SERVING WESTERN COAL MARKETS AND POINTS EAST[1]
(costs given are dollars per ton)

UNION PACIFIC RAILROAD CO.

Territory Served: Serves 13 Western States extending from Kansas City, Mo., and Council Bluffs, Iowa, on the east to Seattle, Wash., and Los Angeles, Calif., on the west.
1972 Coal Tonnage Moved: 7,972,314 T.
Unit Train Tonnage: N.A.

WESTERN PACIFIC RAILROAD

Territory Served: Calif., Nev., Utah
Unit Train Tonnage: None

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[1] pp. 157-161.

Table 33. TRANSPORTATION COST CHARACTERISTICS OF WESTERN BITUMINOUS COAL SHIPPED TO SELECTED CONSUMERS[a],[26]

Consumption point[b]	Origin point[c] (coal district)	Shipping distance (miles)	Minimum trainload tonnage (thousands)	Annual tonnage (thousands)	Ownership of transportation equipment[d]	Average Btu per pound	Cost, cents per ton-mile
040	18	376	(e)	310	2	11,746	2.31
060	19	1,100	6	500	1	11,746	.72
060	14	1,100	-	700	1	11,746	.62
060	14	1,100	-	-	1	11,746	.52
060	15	1,373	6	700	1	10,960	.61
060	15	1,349	6	-	1	10,960	.63
080	17	120	-	75	1	NA	1.82
080	17	224	-	1,250	1	NA	.93
080	19	241	10	-	1	10,960	.96
080	17	32	-	-	1	NA	4.54
080	19	241	-	-	1	10,960	1.10
080	17	16	-	-	1	NA	3.43
170	22	1,200	10	1,000	2	10,290	.48
270	22	800	7	700	1	10,290	.53
270	22	789	10	470	1	10,290	.52
270	22	789	11	1,000	1	10,290	.45
270	22	789	11	1,500	1	10,290	.41
270	22	789	11	1,750	1	10,290	.35
270	22	812	7	300	1	10,290	.13
290	22	215	6	-	1	10,290	.57
290	22	219	6	-	1	10,290	.83
290	22	219	6	800	1	10,290	.95
290	22	243	6	-	1	10,290	.72
290	22	128	7	1,500	1	10,290	.83
300	22	23	-	800	1	10,290	1.86
380	21	64	-	450	1	NA	2.50
460	21	147	-	-	1	NA	1.95
490	16	311	3	1,800	1	9,431	.88
490	20	128	2	1,900	1	12,610	1.12
490	18	360	3	850	1	9,431	.77

[a] Electric utility company consumers represent the largest share of the data. Cement manufacturing consumers are also represented.

[b] For identification of consumption point code numbers, see below.

[c] Several means of collection of data were used in developing this table. Consequently, the point from which coal was shipped is listed by the location of the tipple, the freight rate district or the coalfield. For identification of origin point code numbers, see Table 14.

[d] Cars owned by railroad are indicated by a "1"; "2" indicates shipper-owned railroad cars.

[e] Unspecified.

Code	State
040	Arizona
060	California
080	Colorado
170	Illinois
270	Minnesota
290	Missouri
300	Montana
380	North Dakota
460	South Dakota
490	Utah

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[26] pp. 12-48.

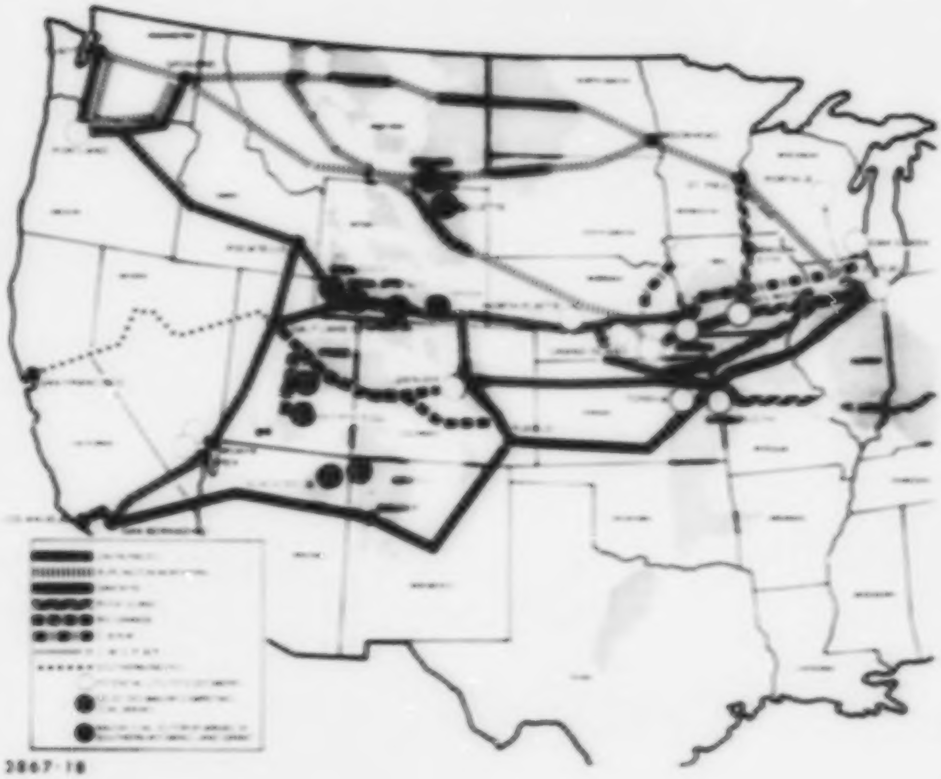

Figure 38. Existing railroads in relation to markets[40]

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[40] p. 85.

Many western railroads are outmoded and in need of substantial upgrading. For example, the Burlington Northern and the Chicago & Northwestern railway systems are but single track lines east and west. They are in need of substantial maintenance-of-way work to strengthen the track for the large number of 100+ ton cars.[54]

The most direct rail line from the western field to midwestern markets is the Chicago & Northwestern which hauls coal from the Powder River Basin in Wyoming to Chicago. Chicago, therefore, has the most immediate access to western coal of all midwest markets. There is some doubt as to the universal acceptance of subbituminous coal in this city due to various technical problems (Section 4). In contrast to Chicago & Northwestern's one-step hauling, Burlington Northern hauls coal from Colstrip, Montana to Minnesota, Colorado, Illinois and indirectly to Oklahoma, Arkansas, Texas and Louisiana.[54] Burlington contemplates hauling coal to St. Louis where it will be barged to Indiana and as far away as Ohio and West Virginia. This can involve quadruple handling in some cases before coal reaches its destination location.

Another major line is the Union Pacific which hauls coal from the Hanna Basin in southern Wyoming to Illinois, Iowa, Nebraska, Missouri, Colorado, and California. The Santa Fe system hauls coal from New Mexico to Arizona and California, while the Denver & Rio Grande hauls Colorado coal into Utah.

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[54] pp. 42, 43.

Costs involved in transporting western coal by rail are strong functions of both distance and method of rail movement. Figure 39 shows a somewhat outdated (1971) but nonetheless relative ranking of modes of energy transport expressed in mills per kilowatt-hour. Compared to rail haulage by conventional methods (denoted here by shuttle train) the integral train concept cuts costs by one half. In 1971 long haul, large tonnage integral trains moved coal for approximately 4 mills per ton mile.[55]

A recent study by the Bureau of Mines correlating economy of haul with type of carrier, shipment size and distance showed that western coal shipped by rail could be competitive with foreign residual fuel oil in selected midwestern fossil fuel markets.[26] The study clearly showed that western coal would not be competitive in the New England and eastern seaboard energy markets. Table 34 gives the results of this study on a delivered cost per million Btu basis. This table shows the best market potential based on local rail coal transportation lies in the East North Central and West North Central regions. Coal from Washington is prohibitively expensive due to long hauls. Rail costs were based on "average practice" of the rail systems as a whole. The average practice as defined here is a least squares calculated line of best fit for selected transportation cost data. Selected transportation cost data are defined as all available data supplied by electric utilities and cement manufacturers.

An interesting comparison of low sulfur western delivered costs to high sulfur local coal delivered costs is given in Table 35 which shows cost penalties to be incurred if

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[55] p. 98

[26] p. 1.

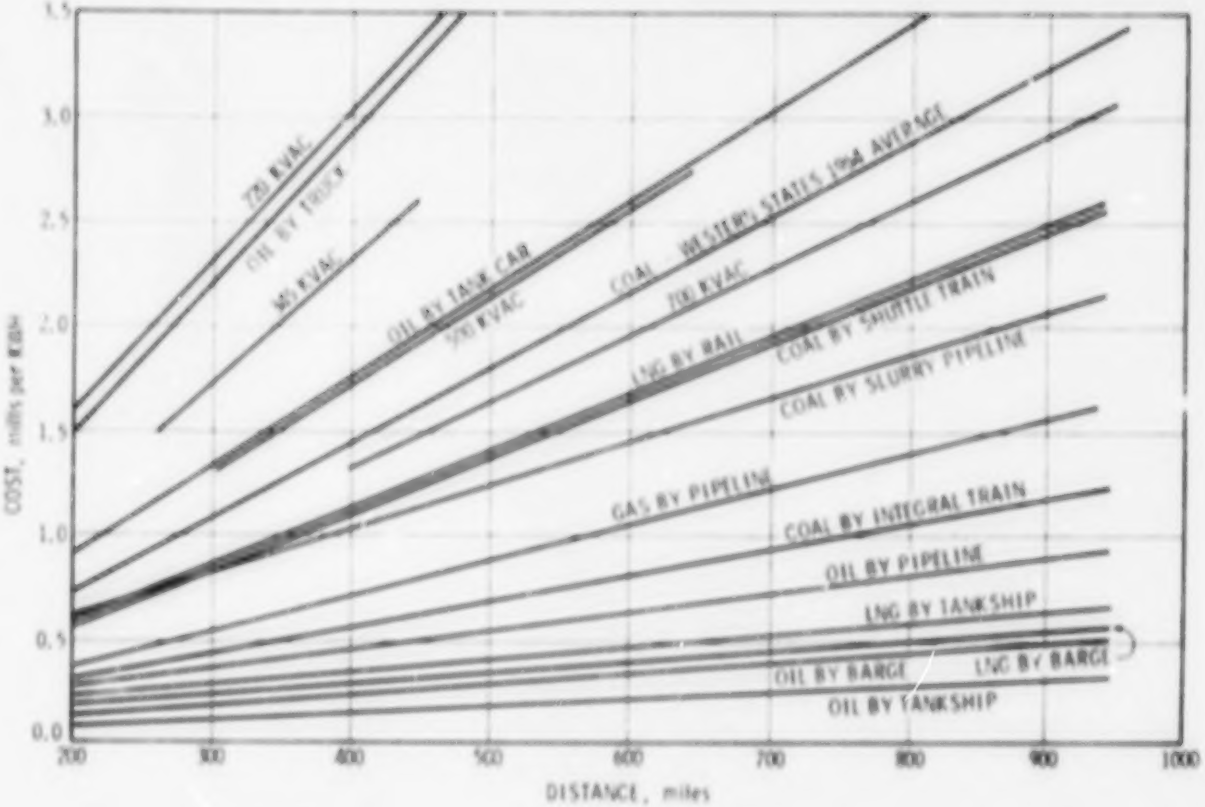

Figure 39. Average relative energy transportation costs[55]

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[55] Evans, H. W. The Economic Future of Western Fossil Fuels. Mining Congress Journal. 57:98, February 1971.

Table 34. COMPARATIVE COSTS OF SUPPLYING COAL FROM WESTERN PRODUCING DISTRICTS AND OIL FROM EAST COAST AND GULF COAST TO EASTERN AND MIDWESTERN MARKETS, 1970[a],[24]

Coal producing district	South Atlantic (Richmond, Va.) Cost ($ per million Btu) Coal	Oil	Competitive cost ratio	Middle Atlantic (New York, N.Y.) Cost ($ per million Btu) Coal	Oil	Competitive cost ratio	New England (Boston, Mass.) Cost ($ per million Btu) Coal	Oil	Competitive cost ratio
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Coal producing district	East North Central (Chicago, Ill.) Cost ($ per million Btu) Coal	Oil	Competitive cost ratio	West North Central (St. Louis, Mo.) Cost ($ per million Btu) Coal	Oil	Competitive cost ratio	[illegible] Cost ($ per million Btu) Coal	Oil	Competitive cost ratio
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[a] [illegible]

[illegible]

[illegible]

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[24] [illegible]

Table 15. COMPARATIVE COSTS OF SUPPLYING HIGH AND LOW SULFUR COAL FROM SELECTED PRODUCING DISTRICTS TO SELECTED CONSUMING REGIONS, 1970a,24

Producer District		Consumer Region								
		East North Central (Chicago, Ill.)			West North Central (St. Louis, Mo.)			East South Central (Vicksburg, Miss.)		
		Cost of coal per million Btu.b		Cost difference	Cost of coal per million Btu.b		Cost difference	Cost of coal per million Btu.b		Cost difference
		Low sulfur	High sulfur		Low sulfur	High sulfur		Low sulfur	High sulfur	
16 and 17	Northern & Southern Colorado (Denver)	0.453	0.312	0.141	0.433	0.312	0.121	0.508	0.283	0.225
18	Arizona & New Mex. (Albuquerque, N. Mex.)	.337	.312	.025	.313	.312	.001	.304	.283	.021
19	Wyoming (Cheyenne)	.345	.312	.033	.332	.312	.020	.415	.283	.132
20	Utah (Salt Lake City)	.530	.312	.218	.519	.312	.207	.583	.283	.300
21	N. & S. Dakota (Fargo, N. Dak.)	.349	.312	.037	.394	.312	.082	.537	.283	.254
22	Montana (Billings)	.348	.312	.036	.438	.312	.126	.429	.283	.146
23	Washington (Seattle)	.805	.312	.493	.819	.312	.507	.901	.283	.618

[a] Cities in parentheses represent point of origin or destination for calculation of distance. Cost in cents/million Btu's.

[b] Low-sulfur coal is from producer district given. High-sulfur coal given is least-cost-available high-sulfur coal (transportation cost + F.O.B. Mine price) for each consumer region. Cost figures are in $ per million Btu.

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[24] p. 12.

western coal is utilized. The lower Btu content of these coals combined with long hauling distances makes them attractive in selected areas only.

3.6.2 Water Transport and Its Applicability

Water transportation of coal by inland river and the Great Lakes is the least expensive way to ship coal. An indication of relative costs between rail hauling and water transportation, based upon data from 1963, is given in Table 36.

Table 36. AVERAGE COAL FREIGHT REVENUES FOR RAIL AND WATER, 1963[56]
(mills per ton mile)

Mode	Revenue
Rail	10.4
Inland rivers	3.0
Lakes/oceans	<2.0

No significant amounts of coal are shipped by water within the western states due to the lack of navigable rivers. However, combined rail/barge and rail/Great Lakes ship systems are expected to handle increasing loads of western coal. The previously mentioned Burlington Northern Railroad exchange with Missouri River carriers at St. Louis is expected to distribute western coal throughout the river system by barge. Plans include the building of extensive loading facilities to accommodate unit train freight with shallow draft barges.

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[56] Anon. Using Waterways to Ship Coal. Coal Age. 79:122, July 1974.

A traffic crisis adverse to the smooth growth of this western coal exchange occurs at the central interchange of the inland river system on the boundary of southern Illinois (Figure 40).[12]

Here the Mississippi, Illinois, Ohio, Cumberland, Tennessee and Missouri rivers converge. All six of these rivers are navigable, and overloaded locks on the Mississippi and Ohio rivers can back water traffic up for hundreds of miles in all directions. Delays of 12 to 16 hours are common with the cost for individual barges falling between $75 and $100 per hour.[12] A major factor in these delays is the inadequate size of locks that can handle large tows of barges only by the time-consuming process of double locking. This bottleneck is being alleviated by the construction of new facilities. Completion is scheduled in about four years. Thus, western coal deliveries by this inland system will be forestalled in the immediate future.

The Great Lakes are forecast to play an increasingly important role in the expansion of western coal utilization. For example, Detroit Edison has recently negotiated a large 25-year contract with Decker Coal Company in Montana.[56] Coal will be shipped from Montana by 10,000 ton unit trains to the Duluth-Superior area. The coal will then be transferred to huge 1,000-foot long by 105-foot wide ships designed to carry 62,000 tons of coal. A sketch of the planned route to the St. Claire Plant is shown in Figure 41. Ice control during the winter months combined with huge storage facilities will increase the yearly capacity.

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[12] pp. 192-197, 193.

[56] p. 125.

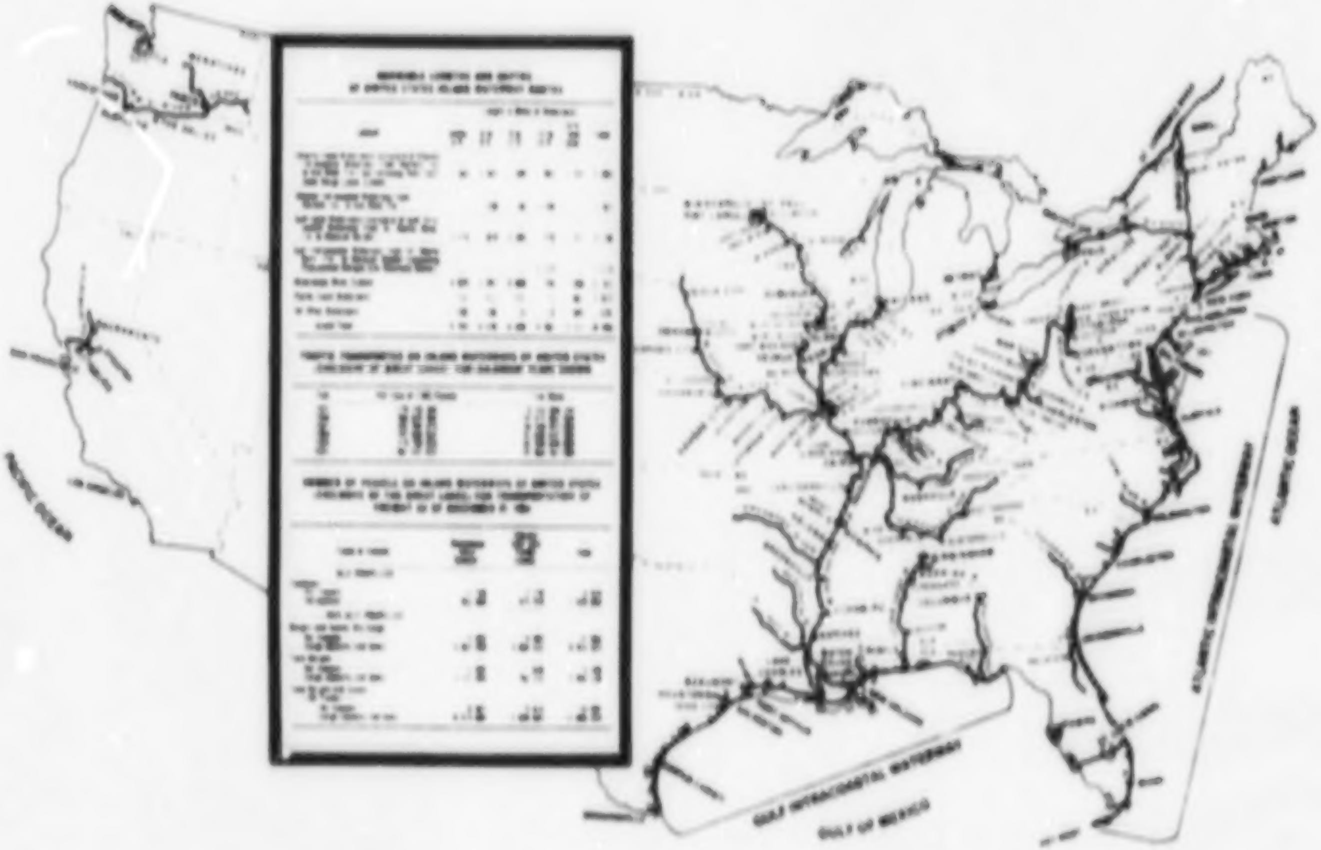
PACIFIC OCEAN
GULF INTRACOASTAL WATERWAY
GULF OF MEXICO
ATLANTIC INTRACOASTAL WATERWAY
ATLANTIC OCEAN

Figure 40. Waterways of the United States[56]

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[56] p. 124.

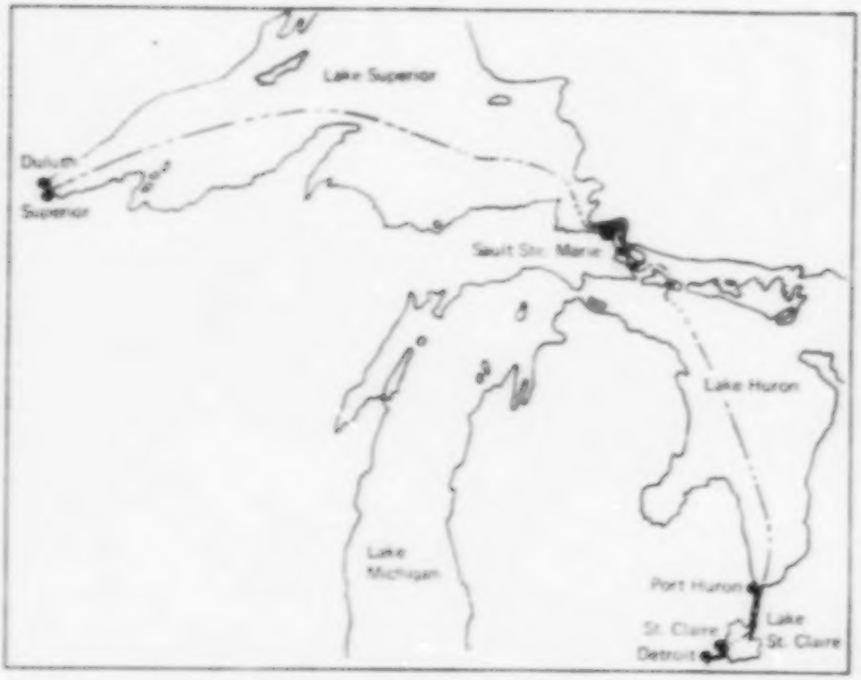
Lake Superior
Duluth
Superior
Sault Ste. Marie
Lake Huron
Lake Michigan
Port Huron
Lake St. Claire
St. Claire
Detroit

Figure [illegible]. Planned Great Lakes Route for Detroit-Edison[54]

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[54] p. [illegible].

3.6.3 Coal Slurry Pipeline Transport

The coal slurry pipeline is a proven transport method. The most dramatic application is the Black Mesa pipeline in Arizona owned by Black Mesa Pipeline, Inc., a subsidiary of Southern Pacific Pipe Lines, Inc. This is the only operational coal slurry line in the United States. A 50/50 water-coal slurry travels 273 miles from the Black Mesa Field to the Mohave Power Plant in Nevada. The route is shown in Figure 42. Figure 43 is an elevation profile map of the pumping stations and distances. This single pipeline can haul over 5-1/2 million tons of coal a year. The system is environmentally attractive because the 18 inch diameter pipeline is buried three feet underground.

The decision to move coal by slurry was one of economics for Black Mesa. The ultimate destination required the addition of 150 miles of new railroad track with a total haul of 408 miles. The slurry line cut 135 miles of this while increasing transport reliability.

Although slurry is more technically complex than rail haulage methods, economy of haul is realized for large-scale operations. The key to any successful slurry system is the slurry preparation process. It must provide a consistent size coal to permit a reasonable balance between pumpability and final dewatering characteristics. If sizing is too fine, pumpability may be good but slurry may be difficult to dewater.[58] Conversely, too large or coarse a sizing results in a heterogeneous slurry which is easily dewatered but which must be pumped at higher velocities to maintain a suspension.[58] Costs rise in either of the above cases.

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[58] Cowper, N. T., T. L. Thompson, T. C. Aude, and E. J. Wasp. Processing Steps: Keys to Successful Slurry-Pipeline Systems. Chemical Engineering. 79(3):59, 59, February 7, 1972.

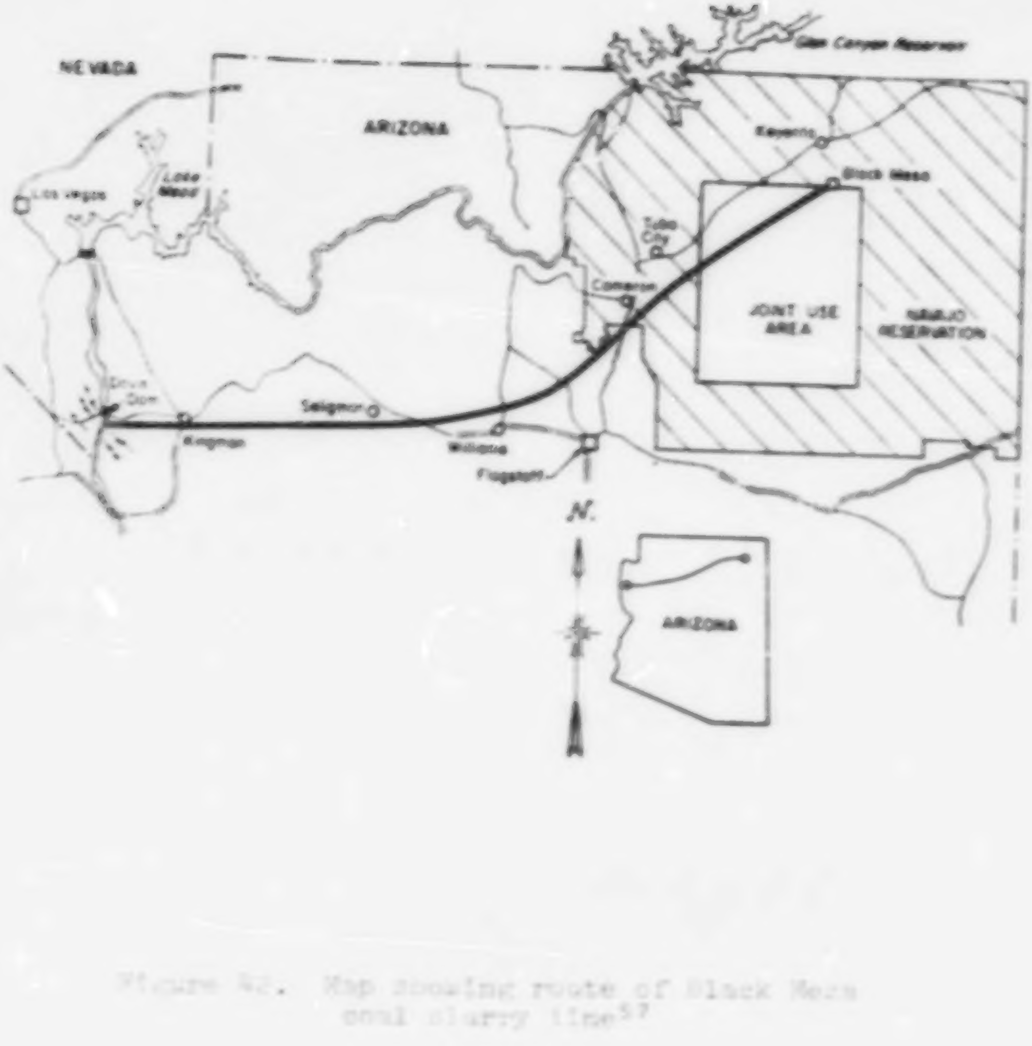
NEVADA
ARIZONA
Glen Canyon Reservoir
Lake Mead
Las Vegas
Kayenta
Black Mesa
Tuba City
Cameron
JOINT USE AREA
NAVAJO RESERVATION
Davis Dam
Kingman
Seligman
Williams
Flagstaff
N.
ARIZONA

Figure 42. Map showing route of Black Mesa coal slurry line[57]

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[57] Technology and Use of Lignite - Proceedings: Bureau of Mines - University of North Dakota Symposium, Kube, W. R., and J. L. Elder, (eds.). Bismarck, North Dakota, May 12-13, 1971. Bureau of Mines Information Circular. 8543. 1972. p. 16.

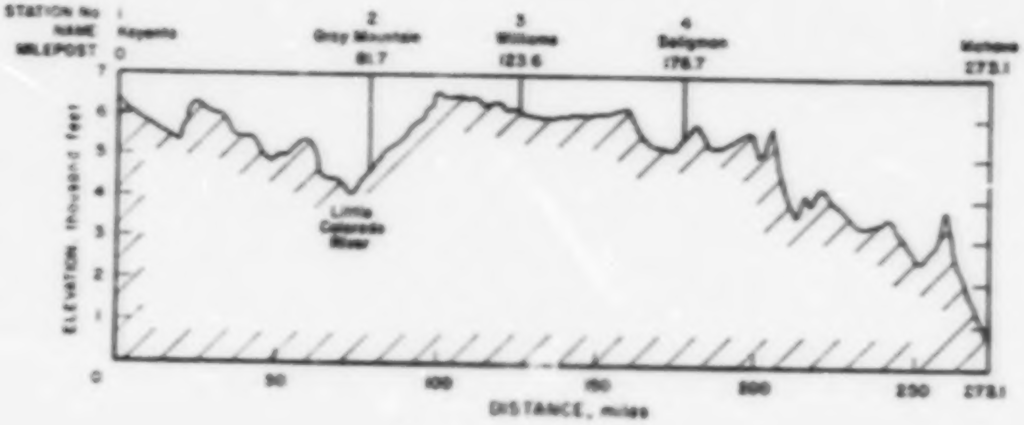

Figure 43. Profile of Black Mesa pipeline[57]

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[57] p. 16.

A workable processing plant is shown in Figure 44. Slurries are stored in highly agitated vessels prior to pumping. The delivered slurry is also stored in large holding tanks where it is continuously dewatered to 25% moisture by centrifugal dryer. The damp coal is then sent to pulverizers where the remaining surface moisture is removed, and the coal is burned conventionally.

Inherent problems with conventional slurry pipelines are the large quantity of water necessary to sustain them and the lowering of the coal's calorific value as a result of the water contact. The excess water not used for cooling tower makeup and ash handling at the Mohave Plant must eventually be evaporated to the atmosphere.[57] In the arid West this is hardly the optimal solution. Thought is being given to hauling coal ash in slurry form back to the mine. This would help fill deep strip mine pits and conserve water.

General slurry transportation costs including preparation costs are shown in Figure 45 for various distances and tonnage. Comparative costs with unit train and EHV (extra high voltage) transmission are shown in Figure 46. These costs are for solid volumes of two to six million tons per year (1970). They include both operating and capital costs and charges.

Coal slurry pipeline networks are envisioned to be the ultimate mode of coal transport in the future as they require less operational labor than either railroads or water transport, making them less susceptible to labor strikes. They appear to be economically advantageous for long distance transport

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[57] p. 29.

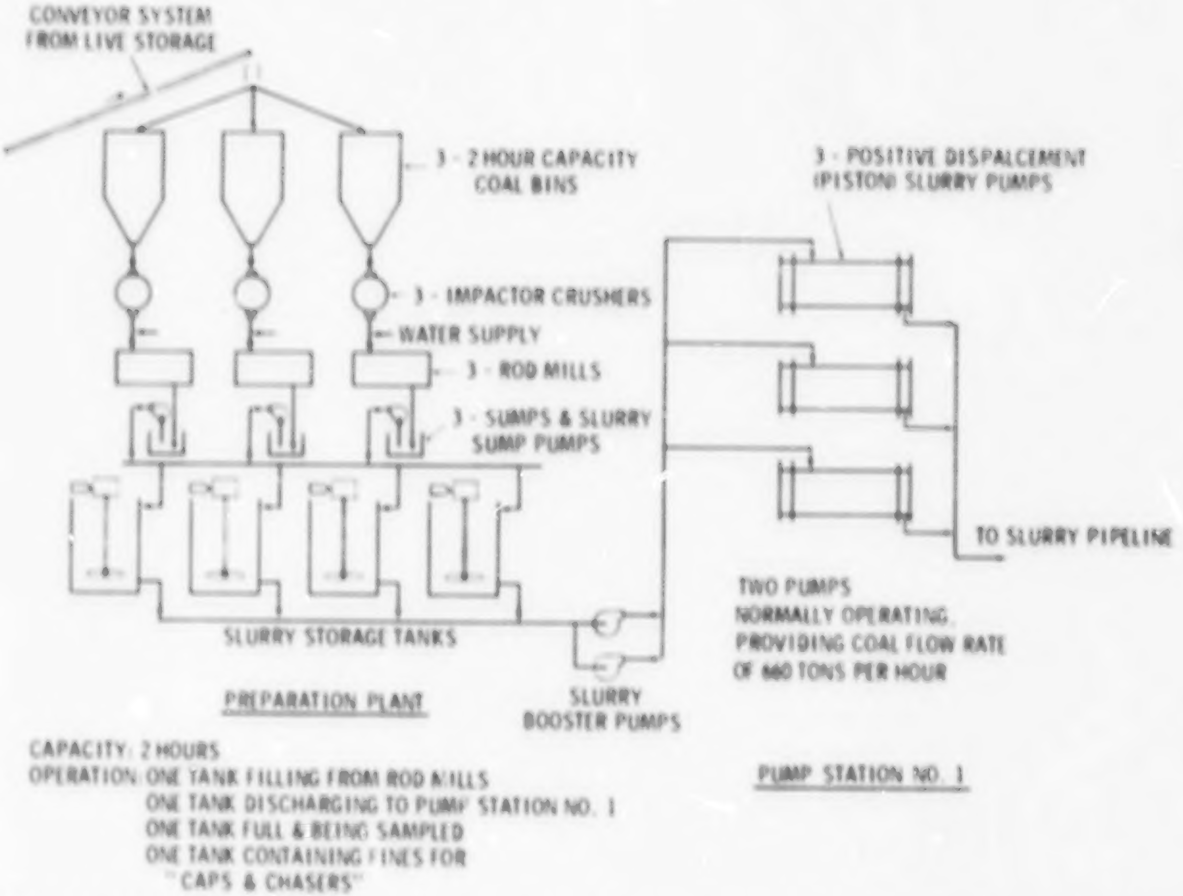
CONVEYOR SYSTEM
FROM LIVE STORAGE
3 - 2 HOUR CAPACITY
COAL BINS
3 - IMPACTOR CRUSHERS
WATER SUPPLY
3 - ROD MILLS
3 - SUMPS & SLURRY
SUMP PUMPS
SLURRY STORAGE TANKS
PREPARATION PLANT
SLURRY
BOOSTER PUMPS
3 - POSITIVE DISPALCEMENT
(PISTON) SLURRY PUMPS
TO SLURRY PIPELINE
TWO PUMPS
NORMALLY OPERATING,
PROVIDING COAL FLOW RATE
OF 660 TONS PER HOUR
PUMP STATION NO. 1
CAPACITY: 2 HOURS
OPERATION: ONE TANK FILLING FROM ROD MILLS
ONE TANK DISCHARGING TO PUMP STATION NO. 1
ONE TANK FULL & BEING SAMPLED
ONE TANK CONTAINING FINES FOR
"CAPS & CHASERS"

Figure 44. Process diagram of preparation plant and one pump station (Black Mesa)[59]

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[59] Anon. Mine to Market Efficiency...Peabody Coals Strong Point. Coal Age. 76:153. October 1971.

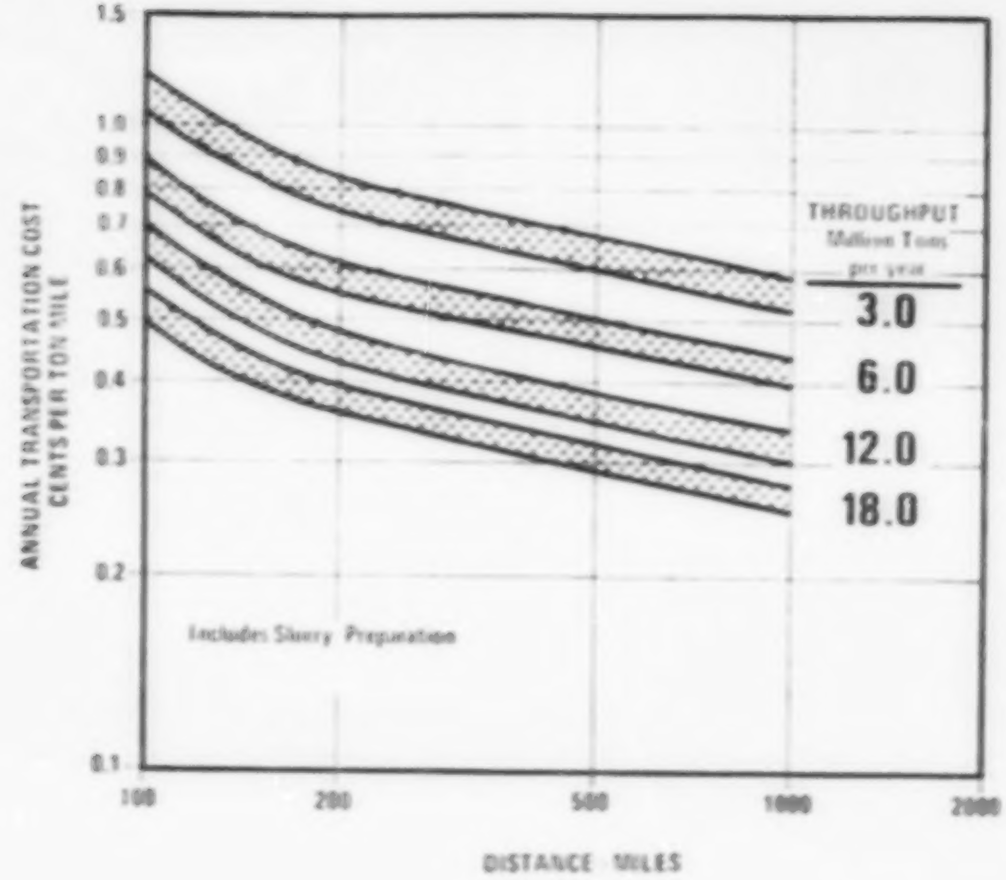

Figure 45. Coal slurry pipeline transportation costs (1970)[12]

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[12] p. 203.

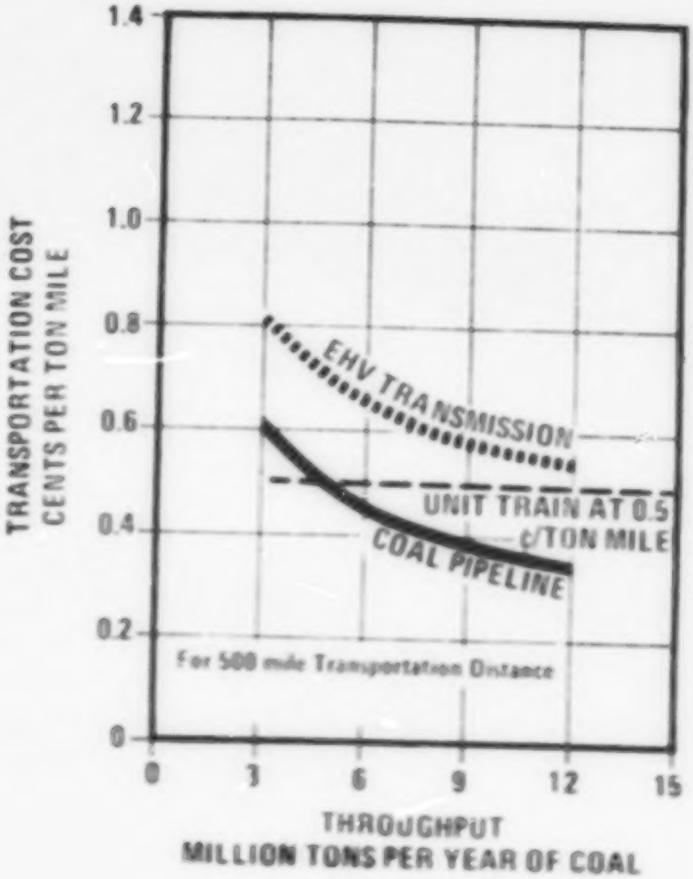

Figure 46. Comparison of alternate modes of energy transportation (1970)[12]

and are environmentally sound. Two projects are currently under study for the U.S. for long distance coal slurry carriage. A 1000-mile coal slurry line connecting low sulfur coal deposits in Colorado to the lower Mississippi valley is planned.[60] Additionally, an 800-mile pipeline is planned to link coal producing areas of Montana, Utah, Wyoming and Colorado to the Pacific Northwest.[60] A significant difference in the slurry medium is proposed in the 800-mile study. Methanol will be used in place of water so that the entire slurry can be burned.

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[12] p. 203.

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[60] Anon. Coal-Slurry Pipelines - A Rapidly Growing Technique. Coal Age. 79:94,96, July 1974.

SECTION 4

WESTERN COAL COMBUSTION

A recent survey (1973) has estimated the number of stoker coal-fired, industrial boilers to be 124,000.[61] The proportions of spreader stokers, underfeed stokers, overfeed stokers, pulverized coal and other types of industrial coal burning equipment of various capacities are displayed in Table 37.

Table 37. POPULATION BREAKDOWN BY BURNER TYPE OF COAL-FIRED INDUSTRIAL BOILERS IN SERVICE IN THE U.S. (1973)[62]
(percentage basis by number)

	Rated Capacity Range, 10^3 lb steam/hr			
	10-16	17-100	101-250	251-500
Underfeed	70	60	20	15
Overfeed	10	15	10	10
Spreader	15	20	50	30
Pulverized	-	-	15	40
Other	5	5	5	5
	100%	100%	100%	100%

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[61] Duncan, L. J., E. L. Keitz, and E. P. Krajeski. Selected Characteristics of Hazardous Pollutant Emissions, May 1973, The Mitre Corporation. EPA Project No. 095A. Contract No. 68-01-0438. p. 72.

[62] Locklin, D. W., H. H. Krause, A. A. Putnam, et al. Design Trends and Operating Problems in Combustion Modification of Industrial Boilers. Environmental Protection Agency Technology Series EPA-650/2-74-032, April 1974. p. 21.

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All of the above equipment is discussed in this section. The fuel burning equipment, boiler, and associated auxiliary equipment for all of these installations are described, and the influence of fuel characteristics on equipment design is discussed.

Eastern, midwestern and western coals burn differently and combustion experience using these coals is compared. Equipment modifications are suggested to improve boiler operation, capacity and efficiency where problems are encountered in converting the boiler to western coal.

4.1 COAL FIRING EQUIPMENT

4.1.1 Underfeed Stokers

4.1.1.1 Single retort stoker

Underfeed stokers of the single retort, ram-fed, side ash discharge type are used primarily for heating and for small industrial units of less than 30,000 lb of steam per hour. As shown in Figure 47, these units are fed from the hopper by a reciprocating ram, or from a screw conveyor on the small units, to a single trough called the retort. The coal moves rearward by means of small auxiliary pushers, then upward to spread over the air-admitting tuyeres.

The single retort horizontal-type stokers are usually limited to 25,000 to 30,000 lb of steam per hour, with burning rates of 425,000 Btu per sq ft of grate area per hour in furnaces having water cooled walls.[*4] For refractory wall furnaces, the maximum burning rate is limited to about 300,000 Btu per sq ft per hour.

[*4] pp. 11-5.

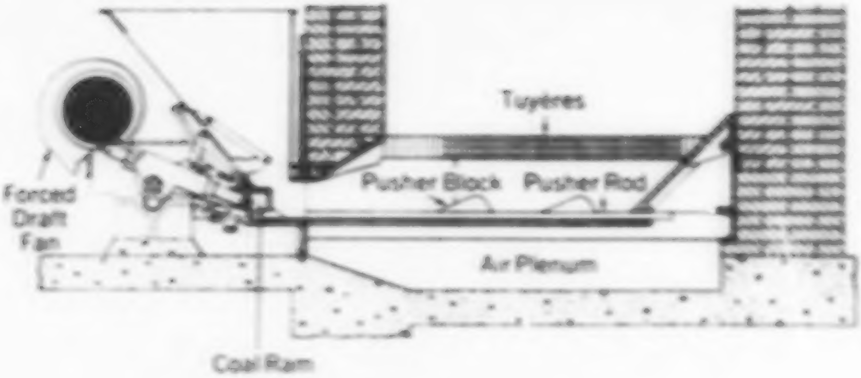
Tuyeres
Pusher Block
Pusher Rod
Forced Draft Fan
Air Plenum
Coal Ram

Figure 47. Single retort, horizontal-feed, side ash discharge underfeed stoker[46]

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[46] p. 11-4.

The burning rates of underfeed stokers are related to the coal ash softening temperature. The burning rates for coals having an ash softening temperature of less than 2400°F must be reduced. Since many New Mexico and Colorado coals have ash softening temperatures above 2400°F, these western coals can be burned at high heat release rates per unit of furnace volume (as shown in Table 38).[63] However, many Montana, Whoming and North Dakota coals have lower ash fusion temperatures, and it is necessary to adjust the feed rates for these coals to maintain a lower fuel bed temperature to prevent clinker formation. When burning low heating value western coal, the burning rate (pounds coal per hour) must be increased to obtain the same heat release rate (Btu/hour) experienced with the eastern or midwestern coal. This, of course means that the western coal must have suitable ignition characteristics to permit complete combustion of the fuel.

Table 38. HEAT RELEASE RATE FOR SINGLE RETORT UNDERFEED STOKER[63]
(heat release rate, Btu/hr/cu ft furnace; 13% CO_2 by volume in gases leaving furnace)

Ratio of area of the water-tube surface exposed to furnace to the total area of the furnace enclosure exclusive of the grate area	Ash Fusion Temperature, °F	
	2,200	2,400
0.20	20,000	40,000
0.24	40,000	50,000
0.26	45,000	50,000
0.34	45,000	50,000

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[63] Johnson, A. J., and G. H. Auth. Fuels and Combustion Handbook. New York, McGraw-Hill Book Company, Inc. 1951. pp. 781, 796. Copyright, 1951, by the McGraw-Hill Book Company, Inc. Used with permission of McGraw-Hill Book Company.

Single retort underfeed stokers are capable of burning caking or moderately caking bituminous coals and certain free burning bituminous coals, and, to a lesser extent, other grades of coal or waste fuels (such as wood refuse) in combination with such coals. The range of agitation imparted to the fuel bed in different stoker designs permits the use of coals with varying degrees of caking properties. This type of stoker is used most widely for burning eastern caking bituminous coals and those midwestern free burning bituminous coals with ash fusion temperatures high enough for successful utilization in the relatively thick fuel beds that characterize underfeed firing. However, fuels ranging from lignite to anthracite have also been burned successfully.

For satisfactory stoker operation, the correct coal particle size must be chosen to prevent particle drifting and the low fuel bed permeability that occurs with fuels having a large amount of fines present. The most desirable size consists of 1-1/4" x 3/4" nut, 3/4" x 5/16" pea, and slack (size of coal which will pass through a 1/4" round hole screen) in about equal proportions.[63] However, bituminous coal of 1 to 1-1/2" nut and slack, which contains not more than 50% slack, can be successfully burned.[63] To permit complete combustion of the coal and to prevent loss of fire caused by air passing through portions of the bed where there is small resistance to air flow, the individual coal lumps should not exceed 1-1/4", particularly when the coal has a hard mechanical structure and cannot be easily broken up by handling. Many friable coals in 2" or even 2-1/2" sizes may be used satisfactorily, however, because the degradation in transit and handling is sufficient to reduce the lumps to sizes that burn well in this type of stoker.

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[63] pp. 781, 781.

The coal characteristics that influence total carbon loss, and therefore boiler efficiency, include rank index, ash content, heating value, and burning rate. Table 39 give the range of carbon losses expected for four kinds of stokers when firing eastern, midwestern and western coals. It is apparent from the table that low ash, low heating value coals generally have high total carbon losses. In the side ash discharge underfeed stoker, for example, the average Montana and Wyoming coals have expected total carbon losses of 4.9% and 3.8%, respectively, compared with a value of 2.0% for average eastern coals and a value of 2.4% for average midwestern coals. For coals from New Mexico and Colorado, one can expect total carbon losses of 2.9% and 2.7%, respectively. The minimum expected total carbon loss at maximum continuous rating for side ash discharge underfeed stokers is 1.5%.

4.1.1.2 Multiple retort stoker

The multiple retort inclined underfeed stoker is still used in many plants, with relatively constant loads or light loads of long duration. This type of stoker can be used with boiler units up to 500,000 lb of steam per hour at burning rates up to 600,000 Btu per sq ft per hour.[46] With the rear end cleaning type multiple retort stoker shown in Figure 48, the fuel is introduced through a coal hopper and fed to inclined retorts and grates by means of coal rams. Dumping grates are used for ash removal in smaller units and with low ash coals where intermittent dumping will not interfere with the load. With large stokers and high ash coals it is desirable to use

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[46] p. 11-5.

Table 39. TOTAL CARBON LOSS

State	Coal Burner											
	OF			SS			UF-SA			UF-RA		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Arizona	-	2.4	-	-	1.0	-	-	2.8	-	-	1.6	-
Colorado	1.5	2.1	2.5	(1.0)	1.1	1.4	1.8	2.7	3.1	(1.0)	(1.7)	3.0
Montana	1.5	3.4	(≈6.0)	≈1.0	1.2	1.5	1.8	(4.9)	(≈5.0)	3.0	(≈5.0)	-
New Mexico	-	2.1	-	-	1.1	-	-	2.9	-	-	1.6	-
North Dakota	-	-	-	-	1.1	-	-	-	-	-	-	-
Utah	1.7	2.0	2.2	(1.0)	1.1	1.1	1.6	2.7	2.9	(1.0)	1.4	1.7
Washington	-	1.6	-	-	1.8	-	-	2.1	-	-	2.1	-
Wyoming	2.6	2.8	3.3	(1.0)	(1.0)	(1.0)	3.0	3.8	(4.0)	(1.0)	(1.0)	(1.4)
Alabama	1.7	(1.5)	2.4	1.1	1.2	1.6	(1.5)	2.1	[illegible]	(1.0)	1.5	2.0
Indiana	1.8	2.0	2.4	1.0	1.0	1.2	1.6	2.4	[illegible]	1.5	1.5	1.8
Illinois	(1.5)	1.9	3.7	1.8	2.4	3.6	1.7	1.5	[illegible]	1.0	1.1	1.3
Iowa	(1.5)	2.1	2.5	1.2	1.2	(1.8)	(1.5)	(2.3)	[illegible]	-	(4.3)	(4.6)
Kansas	(1.5)	1.9	(2.2)	2.6	3.4	-	-	-	3.5	1.5	1.6	1.6
Kentucky	1.5	1.5	2.3	1.0	1.1	1.5	1.5	2.1	(3.2)	(1.0)	1.2	2.1
Missouri	-	2.1	-	-	1.0	-	-	2.4	-	1.3	1.3	1.4
Ohio	(1.5)	1.7	2.2	1.0	1.1	1.2	1.5	2.1	2.9	1.0	1.3	1.7
Oklahoma	1.4	1.6	2.0	1.0	1.0	1 1	1.7	1.9	2.2	1.0	1.2	1.4
Pennsylvania	-	1.6	2.0	1.3	1.6	-	-	2.0	3.3	-	2.0	2.1
Tennessee	1.3	1.5	1.5	1.3	1.5	1.7	1.6	1.8	2.4	2.0	2.2	2.4
West Virginia	1.5	1.5	1.8	1.1	1.3	1.6	(1.5)	2.0	2.9	(1.0)	1.5	[illegible]

OF = overfeed traveling grate stoker
SS = spreader stoker
UF-SA = underfeed stoker, side ash discharge
UF-RA = underfeed stoker, rear ash discharge

Values in parentheses are extrapolated values.

Grate heat release rate for: OF=400,000 Btu/hr/ft^2 grate area; SS=600,000 Btu/hr/ft^2 grate area; UF-SA=400,000 Btu/hr/ft^2 grate area; UF-RA=400,000 Btu/hr/ft^2 grate area.

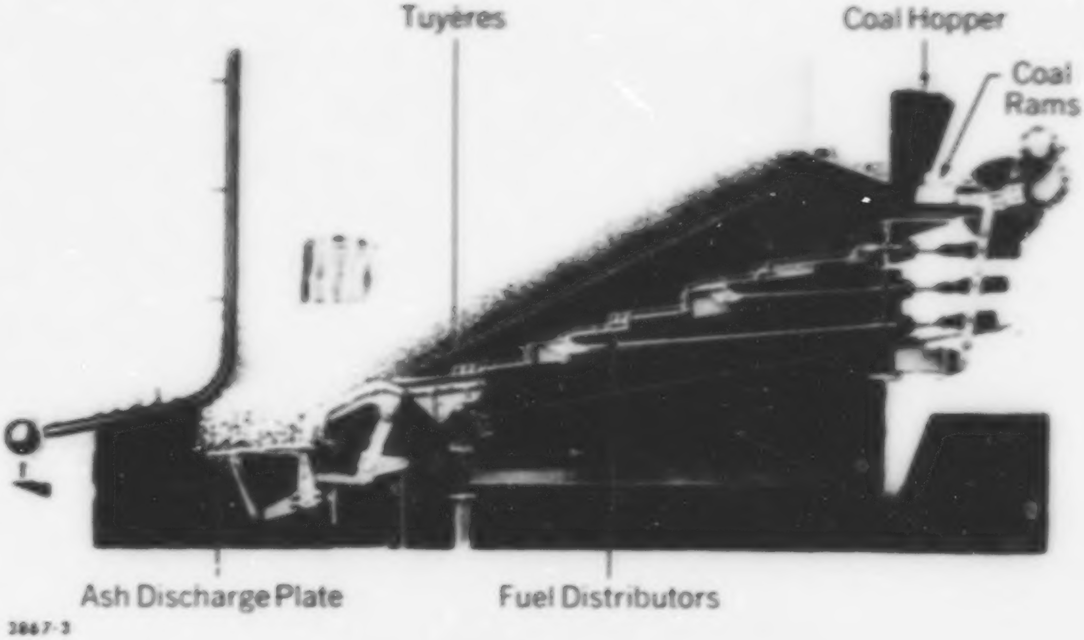
Tuyères
Coal Hopper
Coal Rams
Ash Discharge Plate
Fuel Distributors
3867-3

Figure 48. Multiple retort gravity-feed type of rear ash discharge underfeed stoker[46]

rotary ash discharge in which the ash is discharged to the ash pit through slowly revolving rolls located at the rear of the stoker. This type of ash discharge contributes to reduced carbon losses, better furnace condition, and higher carbon dioxide content of the furnace gas. The continuous ash discharge type of ash removal, which is similar to the manual dump type but with dumping performed automatically by continuous mechanical motion, has a slightly lower comparable efficiency because of a small increase in ash carbon loss.

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[46] p. 11-5.

The most suitable coals for multiple retort stokers are those which have a tendency to cake, but break into a porous fuel bed when agitated.[63] Nonagglomerating coals have a tendency to drift to the rear of the stoker and highly caked coals do not produce a satisfactory fuel bed contour. The use of rear arches causes a redeposit of drifted coal to the front end of the furnace. Such arches also provide turbulence.

Coal size specifications for multiple retort underfeed stokers usually call for 2" nut and slack with not more than 50% of the slack passing through a 1/4" round hole screen, and for the fuel to be delivered across the hopper without segregation.[63] Uniform graduation in coal size from lump to slack should be provided for best results. In general, a coal with 20 to 30% volatile matter is recommended. The use of higher volatile coals causes a marked decrease in efficiency because of smoke formation.

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[63] pp. 792, 791.

Overfire air systems are often used with multiple retort stokers to prevent smoke at low loads or upon a sudden increase of firing rate which causes distillation of a large quantity of volatile gases from the coal bed. Production of relatively high velocity overfire air through rear wall jets has been found to be far more effective than a large number of low velocity openings in the furnace walls.[62] Action of the jets is largely one of setting up sufficient turbulence to mix the furnace gases thoroughly enough to insure proper combustion. Furnace gas turbulence also serves to reduce fly ash carry-over. Since furnaces usually contain enough air for combustion, steam may be satisfactorily substituted for air when desirable. Only enough overfire air or steam should be used to provide the necessary turbulence for complete combustion. Excess overfire air will reduce furnace temperature and boiler efficiency.

The installation of water cooled surfaces at the stoker sidewalls helps to minimize clinker formation when coals having a low ash fusion temperature are burned or when furnaces having inadequate volume are used.[63] The formation of clinkers in such furnaces results from the high temperatures caused by the higher heat release rate per unit of furnace volume needed to meet the load. Clinker formation is a serious cause of grate burnout.

The total carbon loss expected for rear ash discharge underfeed stokers is influenced by the coal's rank index, ash content, and heating value, and the grate heat release rate. In general, the carbon losses increase as the ash content, the rank index, and the grate heat release rate increase, and as the coal heating value decreases. As shown in Table 39, most of the estimated expected carbon losses for Montana coals (where the coal properties are within the range permitting carbon losses to be estimated) exceed the expected carbon losses for eastern and midwestern coals. Colorado coals are expected to have slightly higher carbon losses than eastern or midwestern coals. The Wyoming coals for which analyses are available are expected to have lower total carbon losses than eastern or midwestern coals mostly because of lower ash contents. The minimum expected total carbon loss for rear ash discharge underfeed stokers is 1.0%

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[63] pp. 789, 789.

4.1.2 Overfeed Stokers

As its name implies, the overfeed stoker is fed coal from above and onto a continuously moving grate. The terms chain grate stoker and/or traveling grate stoker are synonymous with the term overfeed stoker. Another class of stokers, the spreader stokers, also employ the chain or traveling grate concept to move the burning coal bed.

The overfeed traveling grate furnace draws coal from a stoker hopper under a vertically adjusted grate, placed across the width of the unit which controls the fuel bed depth. The fuel bed is carried over the several air zones of the stoker by "bar and key" grates or by "chain" grates. The bar and key grate is made of relatively narrow keys or clips mounted on bars or racks which are propelled through the furnace by chain assemblies. In general, the clips of the chain grate form both the coal and the grate surface. The entire coal feeding and burning operation takes place without any agitation of the fuel bed. The features of a chain grate stoker are illustrated in Figure 49.

Traveling grate stoker applications are best suited for industrial and institutional power plants having steady and sustained loads in capacities from 20,000 to 150,000 lb of steam per hour.[64] Although some units of even greater capacities have been built, larger capacities are rare and not recommended.

The furnace side walls are vertical. Arches in the front or rear walls may be used to promote fuel ignition and to provide mixing of the combustion gases by producing turbulence. Arches are necessary for burning low-volatile fuel such as anthracite and coke breeze, or high moisture fuels such as lignite. The use of arches causes many variations in furnace design with chain grate and traveling grate furnaces.

In the absence of arches (in furnaces designed for burning bituminous coals, for example) overfire air jets are necessary to provide turbulence and ignition. Rear jets take the place of a rear arch by forcing the flame toward the front and provide more intense radiation from the flame onto the incoming fuel for ignition. Front jets reverse the flow of gases in a horizontal direction, promoting turbulence by an action similar to that provided by front arches.

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[64] Hollander, H. I. Another Look at the Traveling Grate Stoker. University of Kentucky. (Presented at The Industrial Coal Conference. Lexington, Kentucky, April 1, 1965.) pp. 6, 3.

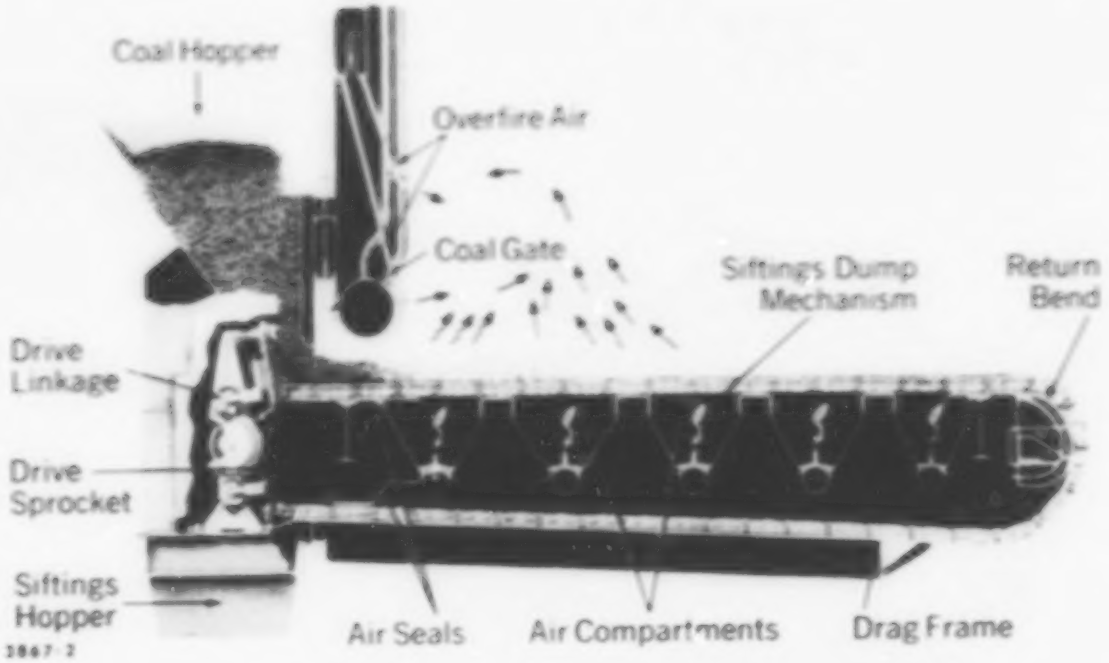
Coal Hopper
Overfire Air
Coal Gate
Siftings Dump Mechanism
Return Bend
Drive Linkage
Drive Sprocket
Siftings Hopper
3867-2
Air Seals
Air Compartments
Drag Frame

Figure 59. Chain grate overfeed stoker[46]

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[46] p. 11-6.

The use of water cooled walls and water cooled arches reduces maintenance on the brickwork, and reduces slag formations in the boiler by reducing the temperature of the furnace gases.

The traveling grate stoker is capable of burning any rank of coal except caking bituminous if properly designed and operated. The recommended size for coals having relatively high free swelling indices is 1-1/2" x 3/8" with uniform size graduation.[64] For friable coals the recommended sizing is 1-1/4" x 0", and for nonfriable coals 3/4" x 0" with not more than 50% passing through a 1/4" round mesh opening.[64] It is possible to burn finer free swelling coals, even mine screenings, but with an increased carbon loss. Uniform distribution of the coal sizes across the grate assists uniform burning.

Although the recommended coal ash content on a dry basis is between 6% and 20% ash, coals having ash contents as high as 30% have been burned in traveling grate furnaces especially designed for this service.[64] Coals burned on a chain grate should have an ash content of less than 15%. A low ash fusion temperature requires a lower grate heat release rate to prevent clinker formation.[64] A traveling grate furnace should be operated to complete combustion within about two-thirds of the grate length. If the coal ash has a low fusion temperature it is difficult to cool the ash sufficiently on the remaining one-third of the grate to prevent clinker formation. The temperatures in traveling grate or chain grate furnaces are usually low enough that ash composition has little effect on refractories.

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[64] pp. 3, 3, 3, 6.

The total carbon losses, as with the underfeed stoker, are influenced by the rank index of the coal, the ash content, the coal heating value and the grate heat release rate. The minimum expected carbon loss at the maximum continuous rating is 1.5%. To reduce ash pit losses and to minimize dust entrainment, the grate heat release rates should be conservative.

The total carbon losses for overfeed stokers increase as the coal ash content decreases, the coal heating value decreases and the grate heat release rate per unit of grate area increases. The total carbon losses as a function of the rank index of the coal are at a minimum when the rank index is 38 (Btu per lb)/(% volatile matter x 10), but the total carbon losses increase as the rank index increases or decreases from this value. The total carbon losses in overfeed traveling grate stokers for eastern, midwestern and western coals are given in Table 39 which indicates that the expected total carbon losses for Montana, Colorado and Wyoming coals are usually higher than for eastern or midwestern coals. The minimum expected total carbon loss for overfeed traveling grate or chain grate furnaces is 1.5%.

The coal feed rate per foot of stoker width is a function of the boiler capacity, the coal rank index and depends on whether the furnace is of arch furnace design or open furnace design. Babcock and Wilcox (1972)[46] state that for high moisture (20%), high ash (20%) bituminous coal, the maximum burning rate is 425,000 Btu per hour per sq ft of grate area. The maximum burning rate of lower moisture (10%), lower ash

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[46] p. 11-6.

(8 to 12%) bituminous coal is 500,000 Btu per hour per sq ft of grate area. Some basic design criteria at maximum continuous rating are given in Table 40. These criteria or guidelines provide a grate and furnace design for good practical overall performance.

4.1.3 Spreader Stokers

The spreader stoker is mostly used in the capacity range from 75,000 to 400,000 lb steam per hour because it responds rapidly to load swings and can burn a wide range of fuels.[46] The modern spreader stoker installation consists of feeder-distributor units (in widths and numbers as required to distribute the fuel uniformly over the width of the grate), specifically designed air-metering grates, forced draft fans for both undergrate and overfire air, dust collecting and reinjection equipment, and combustion controls to coordinate fuel and air supply with load demand. A traveling grate spreader stoker is illustrated in Figure 50.

The distinguishing characteristics of spreader stokers are that coal is injected midway into the surface rather than dumped or pushed in as is the case with overfeed and underfeed stokers. The spreader coal feed mechanism provides a continuous, well distributed supply of fuel at a variable rate as required by the load demand. The most common mechanism is the overthrow rotor design, although several other types are used, depending upon the manufacturer. As shown in Figure 51, the coal is moved from the supply hopper to the overthrow rotor over an adjustable spill plate by means of a reciprocating feed plate. The coal falls onto the rotor

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[46] p. 11-2.

TABLE 40. BASIC DESIGN CRITERIA AT MAXIMUM CONTINUOUS RATING[64]

Ash softening temperature (reducing atmosphere) °F	1900	2000 & above
Grate heat release rate - Btu input/hour/sq ft grate area	300-425,000	450-500,000
Grate coal feed rate - pounds/hour/foot stoker width	See Diagram A	
Furnace heat liberation - Btu input/hour/cu ft furnace vol.	35-40,000	30-35,000
Flame travel - distance from grates to furnace exit feet	Approx. 12	30-40
Excess air leaving furnace - percent	See Diagram B	
Undergrate air temperature - °F		
Free swelling index - up thru 7 1/2	80	300
- above 7 1/2	80	80

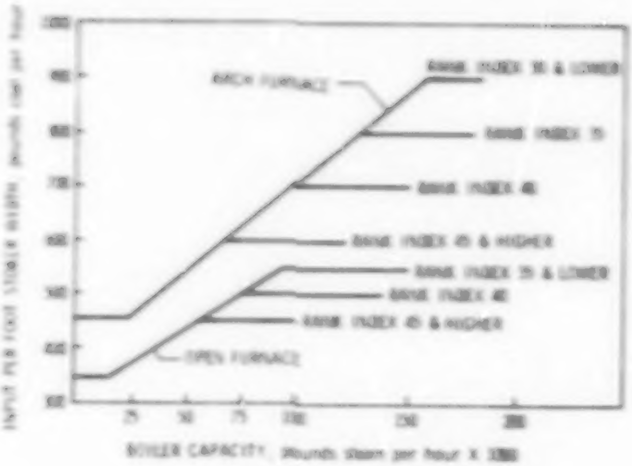

Diagram A

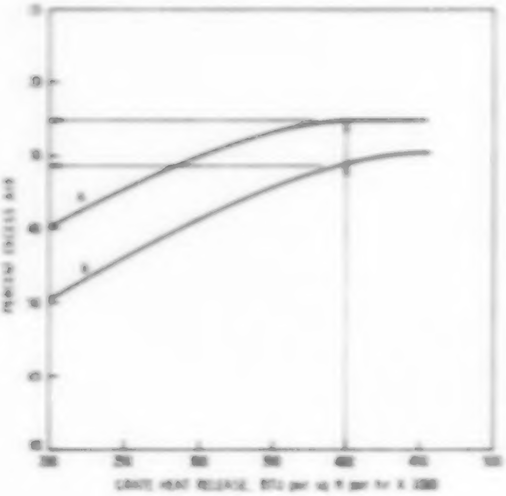

Diagram B

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[64] p. 6.

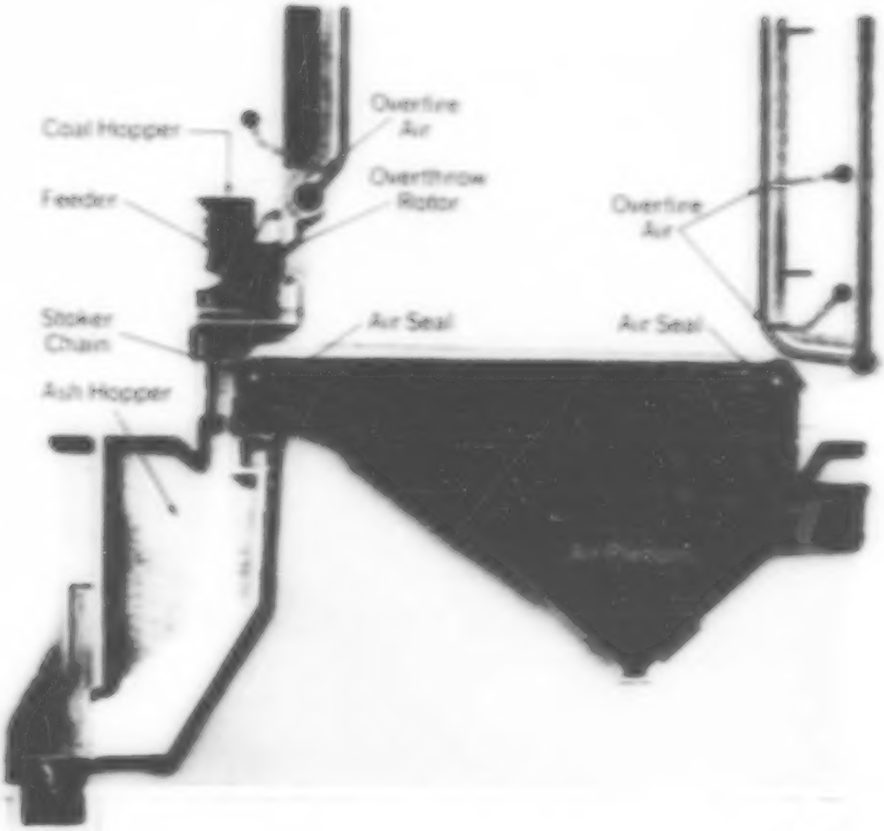
Coal Hopper
Overfire Air
Feeder
Overthrow Rotor
Overfire Air
Stoker Chain
Air Seal
Air Seal
Ash Hopper
Air Plenum
3867-4

Figure 50. Traveling grate spreader stoker with front ash discharge

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[46] p. 11-2.

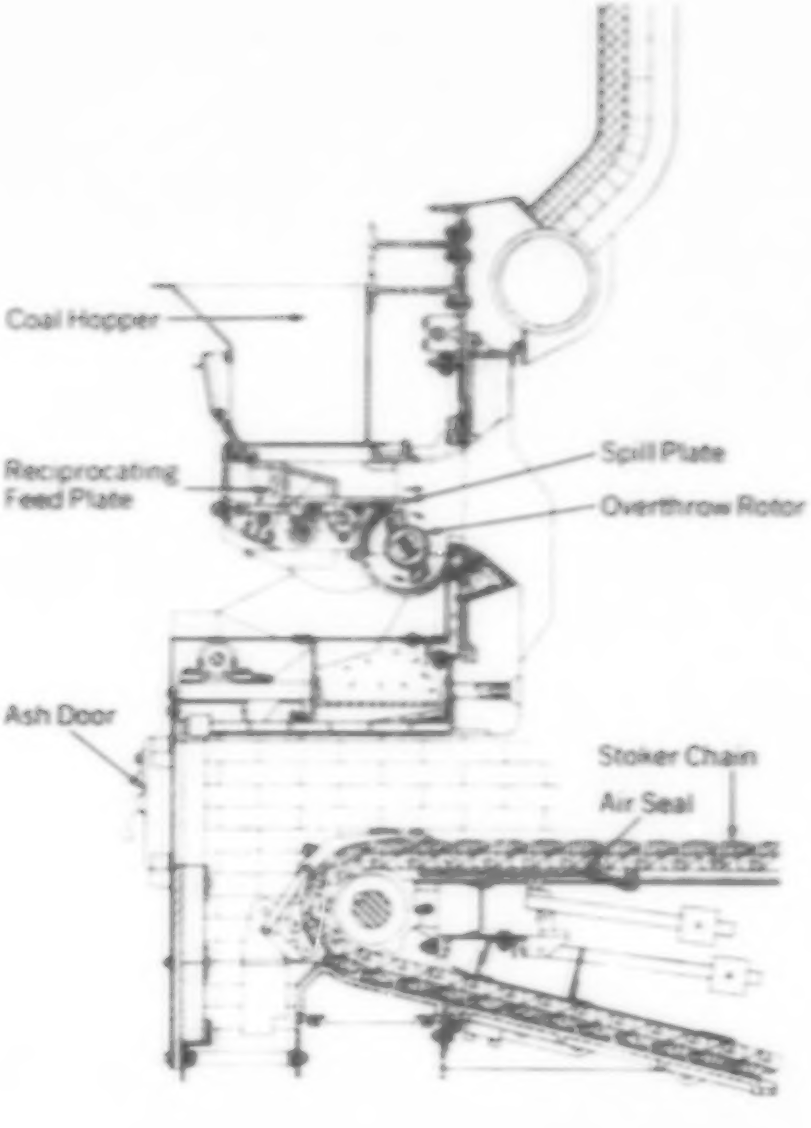
Coal Hopper
Reciprocating Feed Plate
Spill Plate
Overthrow Rotor
Ash Door
Stoker Chain
Air Seal

Figure 51. Reciprocating-feeder distributor and overthrow rotor for spreader stokers[46]

which is equipped with curved blades for uniform coal distribution over the furnace area.

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[46] p. 11-2.

To comply with higher burning rates for large boilers, the continuous ash discharge traveling grate is the preferred grate for spreader stokers.[46] To reduce leakage and stratification of air along the front and rear furnace walls, where it cannot efficiently take part in the combustion process, the traveling grate spreader stoker has self-adjusting air seals at both the front and rear of the grate. Average burning rates of the traveling grate spreader stoker are approximately 70% greater than rates for stationary grate and dumping grate designs. Other continuous cleaning grate designs include the reciprocating and vibrating grates.

Furnaces with refractory walls are sometimes installed with stationary or intermittent dumping grate spreader stokers, but the maintenance costs of such refractories are high. For traveling or continuous cleaning spreader stoker grates where slag or clinker formation adjacent to the stoker would interfere with the movement of the fuel beds, water cooled walls are a necessity. Since arches are not desirable, the water walls are vertical, or nearly so.

The turbulence necessary for successful suspension burning is provided by an overfire air system with guage pressures of 27 to 30 inches of water.[46] The high pressure air jets are customarily placed in two evenly spaced rows in the furnace rear wall and in one row on the front wall.

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[46] p. 11-2, 11-3.

Since a part of the combustion in spreader stokers takes place in suspension, a greater carry-over of carbon-containing particulate matter occurs in the flue gas than with other types of stokers.[63] An increase in boiler efficiency of 2 to 3% results from reintroducing fly carbon into the furnace.[46] The fly carbon from spreader stokers is easily collected in a cyclone type collector. This collector is provided with a selective feature which permits the skimming-off of the coarse carbon-containing particles. The fines are deposited in a hopper for discharge to the ash disposal system.

As the amount of fines in the coal increases and the size of the fines decreases, the carbon loss out of the stack will increase. Units with inherent fly ash traps, and equipped with dust collectors and fly ash returns, will show less loss from this cause than units not so equipped. Coals having a high ash content will show an additional overall efficiency loss. Coals having a low ash fusion temperature will cause clinker formation. These clinkers carry away carbon, resulting in lower boiler efficiency, and also cause higher maintenance.

The ash is removed from stationary grates manually one section at a time by hoe or rake. The practical maximum grate length open to air flow for a stationary grate is 9 ft.[46]

Intermittent dumping grate stokers discharge the ash to pits. These pits may be shallow for firing or clean out if basement space is not available. The length of a dump grate arranged for floor cleaning should be less than 12 ft.[46] With a basement ash pit, the dump grate length should be less than 15 ft.

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[63] p. 795.

[46] pp. 11-3, 11-4.

The traveling grate spreader stokers require either a basement ash pit or a firing level elevation to obtain the necessary ash storage capacity. The recommended maximum net length for traveling grates is about 18 ft.[46]

For vibrating grates and reciprocating grates in spreader stokers, the recommended maximum grate length is 15 ft.[46]

The conventional ash transport systems used for ash removal from ash pits are usually pneumatic conveyors or sluices.

The minimum recommended grate heat release rate is 125,000 Btu per hr per sq ft of effective air-admitting grate area. The maximum recommended rate for continuous ash discharge stokers with traveling grates is 750,000 Btu/hr/sq ft of effective grate area, and for stationary or dumping grate stokers it is 450,000 Btu/hr/sq ft. For continuous ash discharge stokers with oscillating or vibrating grates, the maximum rate should be less than 650,000 Btu/hr/sq ft of effective grate area.

Of the stoker burners, the spreader stoker can burn the widest range of coals. Coal ranks from lignite through semi-anthracite (even anthracite with certain qualifications) can be burned on a spreader stoker.[63] Since most of the volatile matter and tarry hydrocarbons are distilled from the coal particles before they reach the grates, the coal caking properties have little effect upon spreader stoker performance. Coals with high ash content and low ash fusion temperature are more easily burned with spreader stokers than with other stoker types.

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[46] pp. 11-4, 11-4, 11-4.

[63] p. 795.

The feed coal characteristics which most affect spreader stoker performance are the coal sizing and moisture content. Although the spreader stokers will burn fuel sizes ranging from slack to 1-1/4" to 1-1/2" nut and slack, a considerable range in size consist is necessary for uniform fuel distribution on the grate. For example, with double screened coals the coal has a tendency to fall on only one portion of the grate. Coal which is too large and coarse may cause the fuel bed to burn down unevenly, forming clinkers in the areas containing the large sizes.[63] Also, large coal lumps falling on the grate may not be completely consumed.

The use of fuels having a high surface moisture content causes difficulty in obtaining proper coal feeding and coal distribution on the grates because the wet coal particles may stick to the feeder surface and cause erratic performance. However, this problem does not occur for coals with high inherent moisture content, such as lignites.[63] Coals that are fine and dry tend to feed too rapidly.

4.1.4 Water Cooled Vibrating Grate Stokers

Introduced to the American market in the 1950's, this type of stoker is an adaptation of a European design used successfully with many low ranking lignite and brown coals found in central Europe. It is also capable of burning better grades of coal. Because of simplicity, inherent low fly ash carry-over characteristics, and very low maintenance, this stoker has been steadily gaining acceptance and now has replaced larger size multiple retort underfeed stokers in the intermediate range.[46]

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[63] pp. 798,799.

Since the water cooled vibrating grate stoker is capable of burning a wide range of coals, even coals having a high free swelling index can be successfully burned in a porous bed without formation of large clinkers because of the gentle agitation provided by the vibrating grate.

As shown in Figure 52, this type of stoker consists of a tuyere grate surface mounted on a grid of water tubes that are interconnected with the boiler water system for positive cooling. A number of flexure plates support the entire structure, permitting the grid and its grate to move freely in a vibrating action that conveys the coal from the feed hopper onto the grate and finally to the rear of the stoker. The ashes are automatically discharged from the end of the grate to either a shallow or basement ash pit. The grates vibrate intermittently, with the vibration frequency regulated by a timing mechanism.[46]

Slag formation next to the stoker is prevented by the use of water cooled walls. Turbulence and ignition are promoted by the use of a rear arch which extends over about one-third of the fuel bed. A short front arch is added for bituminous

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[46] pp. 11-5, 11-6.

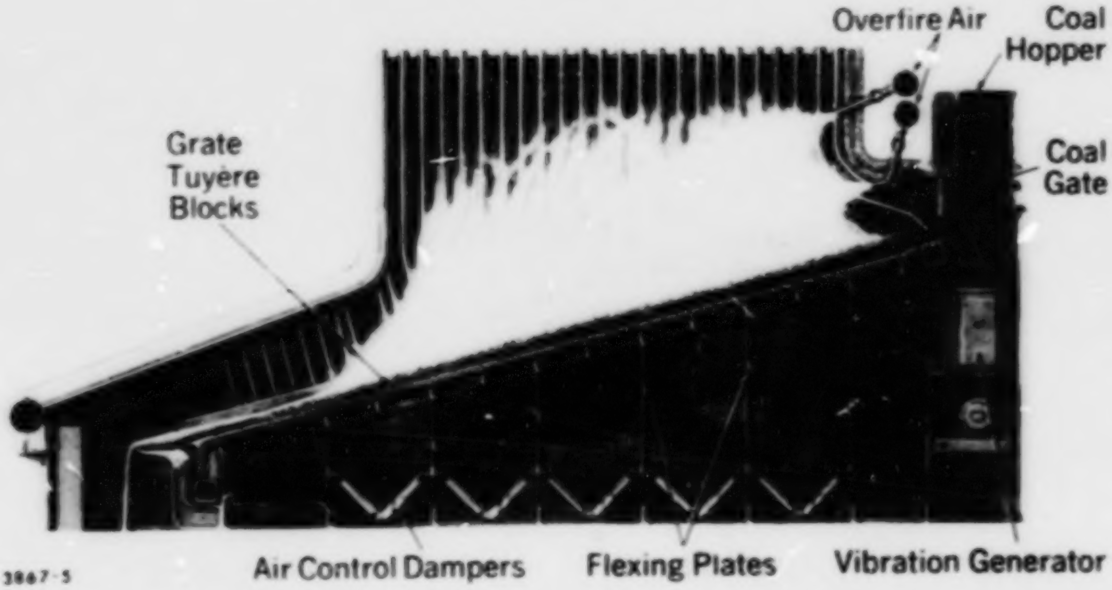
Overfire Air
Coal Hopper
Grate Tuyère Blocks
Coal Gate
Air Control Dampers
Flexing Plates
Vibration Generator
3867-5

Figure 52. Water cooled vibrating grate stoker[46]

coal. Combustion is promoted by the use of high pressure air jets located in the front arch. With low-volatile fuels, a refractory facing over the water cooled front arch may be necessary to promote ignition.

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[46] p. 11-5.

Although burning rates vary with different fuels, the maximum heat release rates should not exceed 400,000 Btu per hour per sq ft of grate area.[46] If the burning rate is held below this value, fly carbon losses are held to a minimum.

4.1.5 Pulverized Coal Furnaces

Because of the capital costs required for small pulverized coal installations, in comparison with similar size stoker installations, pulverized coal units smaller than 100,000 pounds steam per hour are uneconomical.[46] In larger units where the furnace size and configuration are less disproportioned, lower operating costs result from greater efficiency. The furnace must be proportioned so that combustion is completed within the furnace volume for the type of firing used. For pulverized coal furnaces the heat release range is usually between 15,000 and 22,000 Btu per hour per cu ft of furnace volume.

A pulverized coal system consists of: a pulverizer, where the coal size is reduced to the required fineness; a burner, in which the pulverized coal-primary air mixture is mixed with the proper amount of secondary air and delivered to the furnace for combustion; a coal feeder that controls the rate of coal feed to each burner; coal and air conveying lines; and fans that supply air to the pulverizer and deliver the coal-air mixture to the burners. The primary coal characteristics that influence the design of pulverized coal firing equipment are Hardgrove grindability, coal rank, coal moisture content, coal volatile matter content, and coal ash content. The usual limits in these coal characteristics for pulverized coal firing are: (1) maximum total moisture (as fired), 15% (although higher inherent-moisture-content coal such as bituminous or lignite may be used); (2) minimum volatile matter (dry basis), 15%; and (3) maximum total ash (dry basis), 20%.[46]

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[46] pp. 11-6, 9-1.

A pulverizer should have a rapid response to load change and be capable of a long period of continuous operation. It should maintain prescribed performance throughout the life of the pulverizer grinding elements, be able to operate with a wide range of coals, be easy to maintain, and occupy a minimum of building volume. Coal pulverizers are available in capacities up to 60 tons per hour.[46]

The most important factors in the selection of pulverizers are the Hardgrove grindability index and the quantity of the coal to be processed.[46] In pulverized coal-fired boilers, the pulverizer itself is a limiting factor with respect to boiler capacity. Since boiler output is approximatley proportional to the coal heating value, boiler capacity will be reduced when a low heating value western coal is used in a pulverized coal combustion system designed for high heating value eastern and midwestern coals. The relative hardness of a coal is shown by its Hardgrove grindability index; the higher the index, the more easily the coal is pulverized. The capacity of a pulverizer is therefore greater for a coal with a higher grindability index. From available Hardgrove grindability values summarized in Table 41 it can be seen that western coals have lower grindability indices than most eastern and midwestern coals.

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[46] pp. 9-8, 9-6, 9-8.

The moisture content of a coal in a pulverizer should be low enough to prevent the coal from caking on the pulverizer liners and grinding element, permitting free flow of the coal through the machine. In applications where a low heating value, high moisture content coal is burned in a furnace designed for a higher rank coal, larger motors have been required to prevent pulverizer stalling caused by the increased quantity of less free flowing coal. The coal can be dried in its passage through the pulverizer by the use of a preheated air. The maximum mill outlet temperature is determined by the coal rank. The prevalent pulverizer exit primary air-fuel temperatures are given in Table 42. The temperature of the primary air entering the pulverizer may be 650°F or more, depending upon the amount of surface moisture on the coal and the type of pulverizer.[46] The pulverizer wear is influenced by the coal ash content and the silica content of the ash. The higher these quantities are, the more often the abradable mechanical components (such as the ball and race or roll and race) must be replaced.

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[46] p. 9-9.

Table 41. HARDGROVE GRINDABILITY INDEX RANGE OF COALS[47,48]

State	Minimum	Maximum
Alabama	39	87
Illinois	46	75
Indiana	52	68
Iowa	62	66
Kansas	50	61
Kentucky	31	75
Montana	47	56
New Mexico	29	43
Ohio	47	67
Pennsylvania	51	117
Tennessee	30	104
Utah	43	50
Washington	26	105
West Virginia	31	108
Wyoming	41	76
Western Average	37	66
Non-Western Average	44	83

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[47] All

[48] pp. 1-133

Table 42. PREVALENT PULVERIZER EXIT PRIMARY AIR-FUEL TEMPERATURES[46]

Fuel	Exit Temperature, °F
Lignite	120-140
High-volatile bituminous	150
Low-volatile bituminous	150-175
Anthracite	200
Petroleum coke	200-250

Burner performance should be expected to meet the following requirements:[46] (1) the feed rate of coal and air should comply with the load demand over a predetermined operating range; (2) unburned combustible loss should be less than 2%; (3) the burner should not require adjustments to maintain flame shape; (4) only minor maintenance should be required; and (5) the burner should operate safely under all conditions.

The burners used most frequently are the circular burner and the cell burner which have maximum capacities of 165,000,000 and 495,000,000 Btu per hour, respectively.[46] These burners each have a central impeller, located at the burner's center, which promotes mixing of the fuel and the secondary air. The turbulence necessary to mix the fuel and air and produce short, compact flames is produced by register doors that introduce secondary air tangentially around the flame. The cell burner differs from the circular burner by having several gas "spuds". These are gas pipes with multiple holes at the end to discharge gas for ignition at the burner throat, located in a circle surrounding the impeller. Each spud has a circular flame holder to stabilize ignition at low inputs.

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[46] pp. 9-8, 9-11, 9-11.

Although either burner type can be equipped to fire any combination of the three principal fuels, combined pulverized coal-oil firing should be restricted to short periods to prevent possible coke formation on the pulverized coal element.

Burner effectiveness is judged by: (1) compliance of full fuel and air feed rate to boiler load demand over a predetermined operating range; (2) combustion process efficiency; (3) physical size and complexity of the furnace and burners in comparison with the limitations of space, weight, and flexibility imposed by the service conditions; (4) ability of the burner to meet accepted maintenance standards; and (5) ability of the burner to operate safely under all operating conditions.

It is necessary to provide auxiliary igniters for starting up the burner or for maintaining the flame of a burner being fired with moist or low volatile coal. For most coals, it is possible to maintain ignition without an auxiliary igniter down to one-third capacity in the boiler. It may be necessary to use the igniters when burning a coal having less than 25% volatile content even at high boiler loads.[46] It is important that the igniter be activated when ignition is momentarily lost to prevent explosive reignition from an adjacent burner.

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[46] p. 9-12.

4.2 COAL BURNING EQUIPMENT SELECTION GUIDELINES

Roberson summarized the operating characteristics of stokers and pulverized coal burning equipment.[65] His data are presented in Table 43. The editors of Power magazine recently compiled a comparison of the attributes for three widely used stoker types, namely the spreader stoker;chain and traveling grate stokers; and the underfeed stoker.[66] The traveling grate type stokers were preferred over the agitating grate type for all three stoker types. The comparison data for all three stoker types compared are shown in Table 44. Excpet for the inability to maintain smokeless combustion at all loads and the high flyash discharge, the spreader stoker appears to be the most favorable to operate.

4.3 BOILERS

Steel boilers are usually categorized as fire-tube type and water-tube type. The boiler types are described below, with a discussion of their utilization, capacities, design characteristics, firing methods, fuels used, and influence of fuel characteristics on boiler design and operation.

The proportions of the various industrial boiler types in capacity ranges of 10,000-16,000, 17,000-100,000 and 101, 000-250,000 pounds steam per hour are given in Table 45.

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[65] Roberson, J. E. Selection and Sizing of Coal Burning Equipment. Power Engineering. October 1974. pp. 42-45.

[66] Anon. Power from Coal - Part II, Burn Coal on Fuel Beds in Small Industrial Boilers. Power. March 1974. pp. S-30 - S-37.

Table 43. COAL BURNING EQUIPMENT OPERATING CHARACTERISTICS[65]

Pulverized

1. Load range is wide and varies with the number and type of pulverizers.
2. Flyash carry-over in the flue gases is high, and it is finer than the flyash from the spreader stokers. Therefore, although the boiler must be designed to prevent erosion, the allowable flue gas velocity is somewhat higher.
3. Initial cost for pulverized coal equipment is about the same as for spreader stokers at 250,000 lb/hr. It becomes less expensive above these capacities.
4. Pulverized coal equipment can burn a very wide range of coal.
5. Maintenance costs for pulverizers vary considerably with types of coal.
6. Response to load changes is very fast.
7. Coal sizing to a pulverizer is 3/4 in. x 0. Coal segregation is no problem.
8. Repairs and maintenance on pulverizers may be conducted while the boiler is in operation by taking one of several pulverizers out of service at a time.

Vibrating Grate Stoker

1. A wide load range-form banked fire to maximum capacity.
2. Low flyash carry-over unless the unit is overloaded.
3. A dust collector may be required, depending upon local conditions.
4. Sizing and distribution of coal is important.
5. Caking coals have been burned on this stoker.
6. Water-cooled grates tend to reduce grate maintenance when properly designed.
7. Burning rate is usually about 400,000 Btu/sq ft-hr with a furnace heat release of 30,000 Btu/cu ft.

Chain and Traveling Grate Stoker

1. Wide load range from banked fire to maximum capacity.
2. Low flyash carryover in the flue gases; a dust collector is not usually required.
3. Initial cost is more than for an underfeed stoker.
4. Ash softening temperature should be reasonably high, about 2200°F or higher.
5. Maintenance costs are generally low.
6. Response to load changes is about medium, faster than the underfeed but slower than the spreader.
7. Coal sizing should be 1 in. x 0 with approximately 20% to 50% through a 1/4 in. screen.
8. Coal should have a minimum ash content of 7% on a dry basis to protect the grates from overheating.
9. Sensitive to changes in coal sizing and distribution.
10. Offered for a maximum continuous burning rate of 425,000 Btu/sq ft-hr with high moisture (20%), high ash (20%) bituminous coals, such as that from some districts in Illinois, and 500,000 Btu/sq ft-hr with lower moisture (10%), lower ash (6-12%) bituminous coal, such as that from Kentucky. Furnace heat release should be a maximum of 30,000 Btu/cu ft for water-cooled furnaces.
11. Large (above 70,000 lb/hr) front arch, chain grate stokers should have a maximum heat release of about 7 MBh ft (MBh = million Btu) of stoker width for Kentucky coal, depending upon the volatile matter and heating value.
12. Strongly caking coals are not suitable for conventional chain or traveling grate stokers.

Table 43 (continued). COAL BURNING EQUIPMENT OPERATING CHARACTERISTICS[65]

Underfeed Stoker

1. A wide load range banked fire to maximum capacity.
2. Low flyash carryover with the flue gases, provided the stoker is not overloaded.
3. Initial cost is low compared to other stokers.
4. Ash softening temperature should be 2500°F or above for best operation. Coals with ash softening temperature of 2200°F to 2500°F may be utilized, however, the heat release rate per square foot of grate area must be reduced about 20%.
5. In general, maintenance costs are higher than for other stokers.
6. Response to load changes is rather slow, because of the relatively large fuel bed.
7. Coal sizing should be 1-1/4 in. x 0, nut and slack, with not more than 50% through 1/4 in. screen to obtain proper distribution on the grate.
8. The free swelling index should be below about seven to maintain proper fuel distribution in the furnace and to keep maintenance to a minimum.
9. Grate heat-release rate should be no more than 425,000 Btu/sq ft and a maximum furnace heat release rate of 35,000 Btu/cu ft for water-cooled furnaces.

Spreader Stoker

1. Turn down or load range is generally from 1/3 load to maximum capacity. With additional equipment, minimum load can be decreased to about 1/6 of maximum load.
2. Since about 75% of the coal burns in suspension, the flyash carryover is high. A dust collector is always required. A precipitator may be required depending upon the air emission regulations.
3. To obtain the best reasonable efficiency, the flyash collected in the boiler hoppers must be reinjected onto the stoker grate.
4. Initial cost of a dumping grate spreader stoker is the lowest, with the pulsating or oscillating grate next, and the traveling grate the highest.
5. The spreader will burn with little difficulty a wide variety of coals of different fusion temperatures and different coking indices.
6. In general, maintenance costs are approximately the same as for a chain grate.
7. The spreader stoker has a very fast response to load swings.
8. Coal sizing should be 3/4 in. x 0 with no more than 30% through a 1/4 in. mesh. The pulsating or oscillating grates should be fired with coal having an ash softening temperature of above 2300°F to ensure proper fuel bed and [illegible] the grates.
9. Spreaders are designed for burning rates from 450,000 Btu/sq ft-hr for dumping grates to 650,000 Btu/sq ft-hr for pulsating or oscillating grates, to 750,000 Btu/sq ft-hr for traveling grates. Furnace heat release should be a maximum of 30,000 Btu/cu ft.
10. On large spreaders (above 75,000 lb/hr steam capacity) the heat release per foot of stoker width must also be considered, and will vary from about 9 MMBtu/ft-hr to 13 MMBtu/ft-hr depending upon the amount and method of flyash reinjection.
11. Some mention should be made of the two types of reinjection generally used: pneumatic and gravity types. The gravity type is much preferred for the higher steam capacities, (above 75,000 lb/hr) if equipment arrangement and building space is sufficient. As the name implies, the flyash flows by gravity from the boiler hopper and is reinjected on the stoker grates. The stoker should be lengthened to accommodate this gravity return.

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[65] pp. 42-45.

Table 44. STOKER EQUIPMENT COMPARISONS[66]

Unit has the ability to:	Spreader	Chain and Traveling Grate	Underfeed
Increase load rapidly	Excellent	Fair	Fair
Minimize carbon loss	Fair	Fair	Fair
Overcome coal segregation	Fair	Poor	Poor
Accept a wide variety of coals	a	Poor	Poor
Burn extremely fine coal	Poor	Poor	Poor
Permit smokeless combustion at all loads	Poor	Good	Good
Minimize flyash discharge to stack	Poor	Good	Good
Maintain steam load under poor operating conditions	Good	Poor	Poor
Minimize maintenance	Good	Good	Fair
Minimize power consumption (stoker and boiler auxiliaries)	Good	Good	Good
Handle ash and cinders easily	Excellent	Good	Fair

[a] Traveling grate type is rated excellent, agitating type is rated fair

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[66] p.S-30. Reprinted with permission from POWER, March 1974.

Table 45. POPULATION BREAKDOWN BY BOILER TYPES[67]
(percentage basis by number)

	Rated capacity range 10^3 lb steam/hr		
	10-16	17-100	101-250
Water-tube boilers			
Packaged	15	55	25
Field erected	7	24	75
Fire-tube boilers			
Packaged Scotch	30	10	--
Firebox	25	10	--
Horizontal return tubular	20	1	--
Misc. (locomotive type, etc.)	3	nil	--
Total	100%	**100%**	100%

4.3.1 Fire-Tube Boilers

Fire-tube boilers are used for heating systems, for industrial process steam, or as portable or mobile boilers. They are built with capacities up to about 22,000 lb steam per hour. The low pressure heating boiler is limited to 15 psig steam pressure and the power boiler to 400 psig steam pressure.

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[67] Barrett, R. E., S. E. Miller and D. W. Locklin. Field Investigation of Emissions from Combustion Equipment for Space Heating. Battelle Columbus Laboratories, EPA Contract No. 68-02-0251. June 1973. p. 8.

The fire-tube boiler consists of an external or an internal furnace where the fuel is burned, and a number of water-surrounded tubes through which the combustion gases pass. An external furnace has walls made up of refractories, and an internal furnace is surrounded by water walls.

The horizontal return tubular fire-tube boiler has been used for industrial processing applications in small industrial plants and for heating large buildings. As shown in Figure 53, the boiler consists of a cylindrical shell with flat ending closures, between which are supported a large number of horizontal fire tubes. The fuel is burned in an external furnace beneath the front portion of the shell. The hot combustion gases from the furnace rise to the bottom of the shell, pass over a bridge wall and sweep over the shell to the rear of the installation. The hot gases then enter the horizontal tubes and return to the front of the boiler before being discharged. The water circulates down the shell walls, then up past the tubes. The boiler has a large capacity and a large steam release surface.

The short firebox boiler shown in Figure 54 is a horizontal, two-pass fire-tube boiler. The furnace, located beneath the front portion of the shell, may have front, side, and lower rear walls made of refractories, or it may be of the water-leg type. The upper rear wall of the furnace is formed by the front tube sheet of the first tube pass. The second tube pass is located above the first and ends over the furnace. The gases from the furnace immediately enter the first tube pass, travel through the rear smoke box, reverse direction and travel through the second tube pass, and then are discharged. The boiler has a large water capacity and an adequate heat release surface.

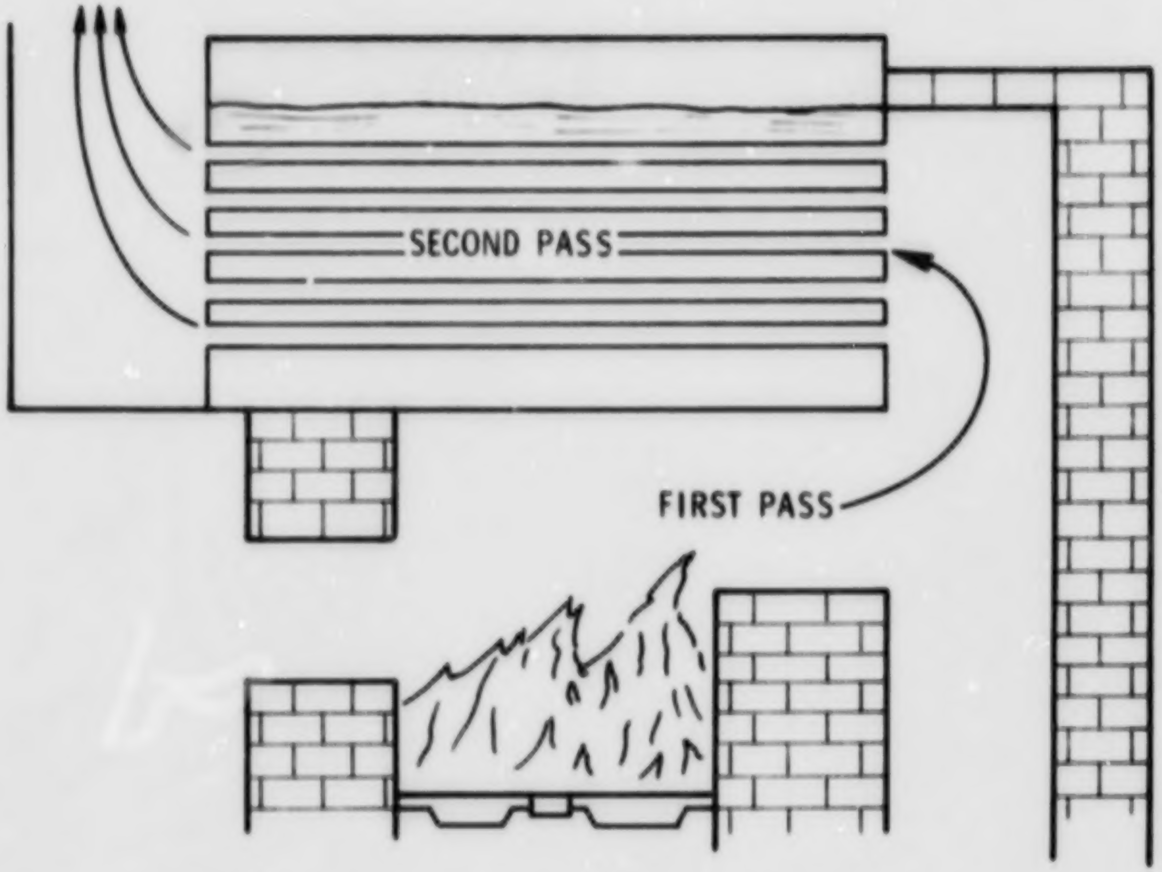
SECOND PASS
FIRST PASS

Figure 53. Horizontal return tubular boiler[68]

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[68] Shields, C.D. Boilers - Types, Characteristics, and Functions. New York, F. W. Dodge Corporation. 1971. p. 19.

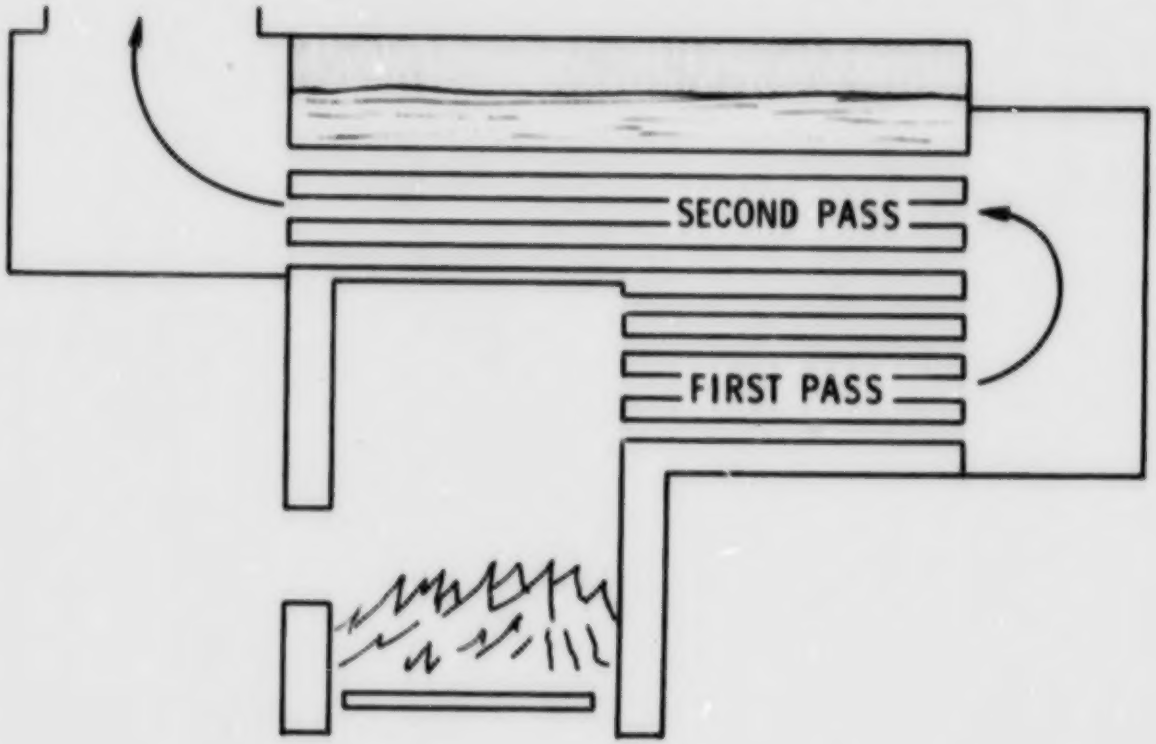
SECOND PASS
FIRST PASS

Figure 54. Short firebox boiler[68]

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[68] p. 22.

The compact boiler shown in Figure 55 has a horizontal fire-tube boiler consisting of a shell with two passes of tube attached to tube sheets inside the end enclosures. The furnace, located under the front portion of the shell, may be of the external or internal type. The hot gases from the furnace pass over the lower half of the shell, travel to the rear of the boiler where they turn, and travel through the first tube pass to the front smoke box, reverse direction, pass through the second tube pass and then are discharged. Boilers with internal furnaces have good water circulation and steaming characteristics. The external furnace boiler has sluggish water circulation and steaming characteristics. The compact fire-tube boiler has higher efficiency than other types of fire-tube boilers.

The Scotch boiler, shown in Figure 56, consists of a cylindrical shell with one or more cylindrical internal furnaces built into the lower portion of the boiler and one or more tube passes attached to the tube sheets placed at the rear combustion chamber and front smoke box. The furnace itself is a large-diameter tube which is not normally refractory lined, but usually has flame shaped throat refractory at the oil or gas burner location. Since it is not possible to alter the furnace size, a Dutch oven is installed when it becomes necessary to increase the furnace volume. A Dutch oven is simply a burning chamber lined with water cooled brick and a stationary grate.[68] The combustion gases flow through the furnace to the combustion chamber, then enter the tube pass (or passes) and are discharged. Small capacity Scotch boilers have adequate water circulation, but water circulation in large units is sluggish, especially at start up.

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[68] p. 122.

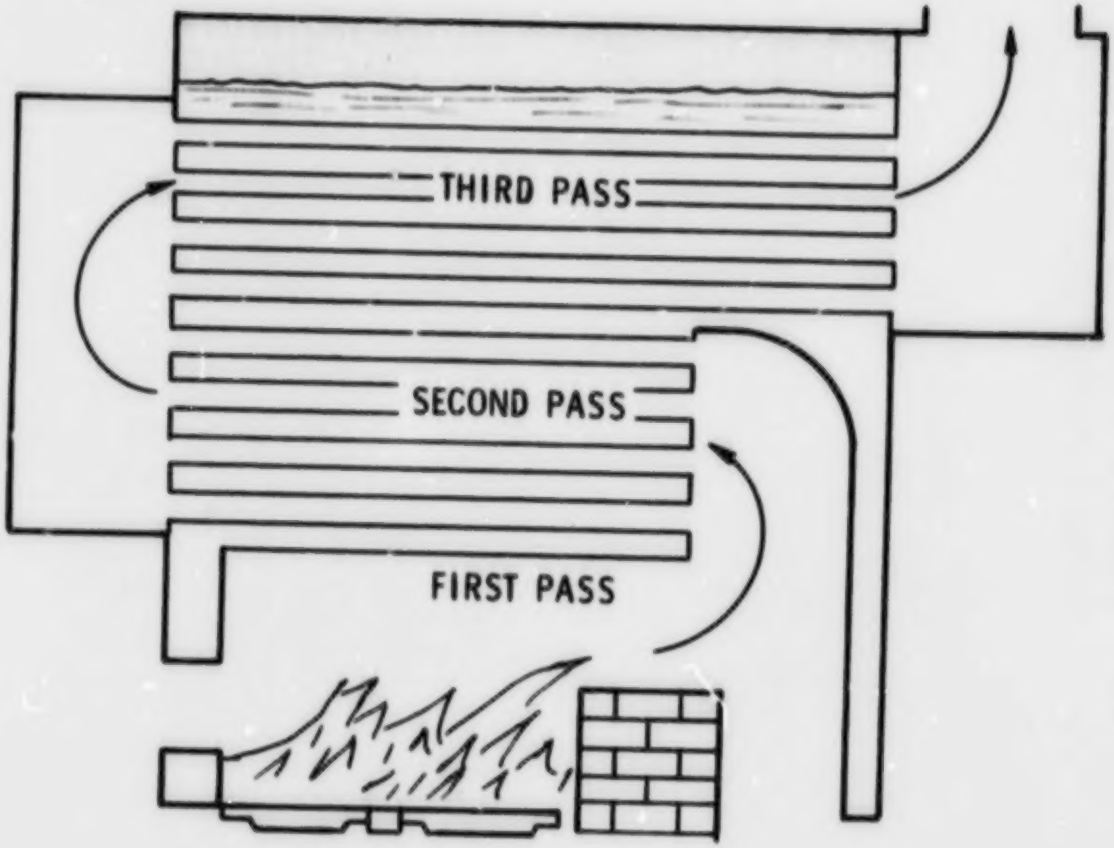
THIRD PASS
SECOND PASS
FIRST PASS

Figure 55. The compact boiler[68]

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[68] p. 23.

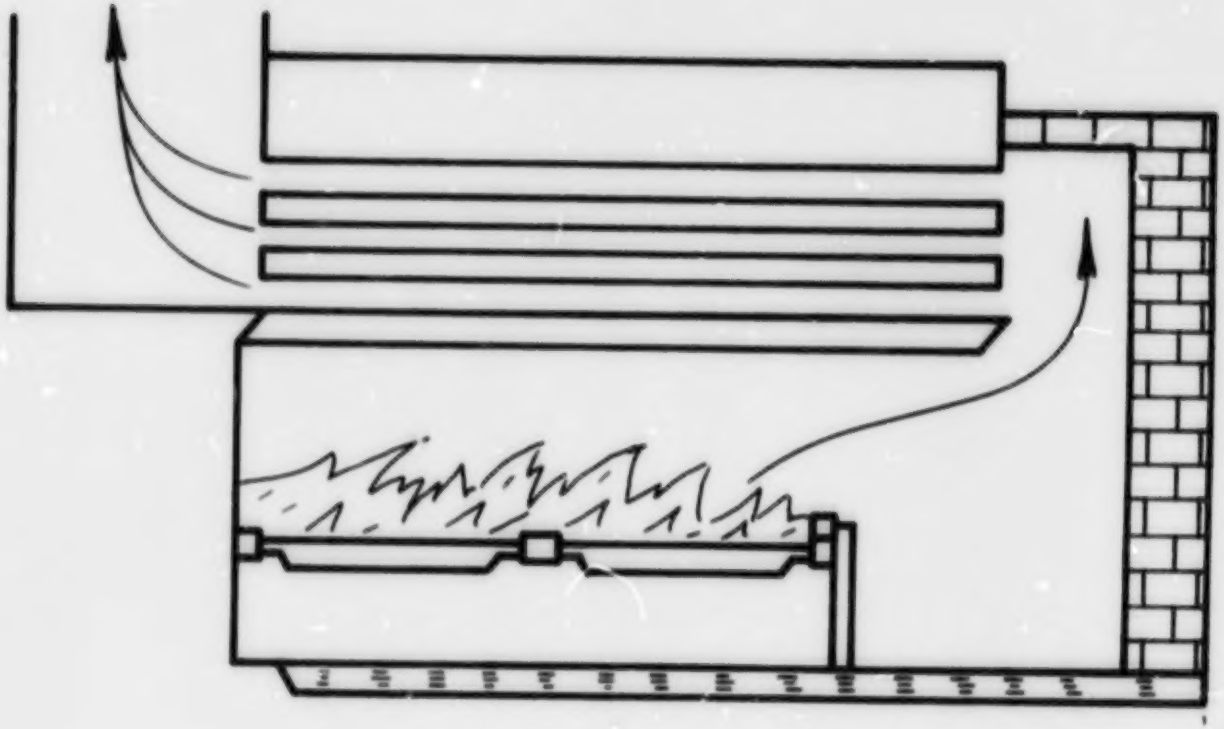

Figure 56. Coal-fired Scotch boiler[68]

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[68] p. 24.

Although fire-tube boilers are usually fuel oil or gas fired, it is technologically possible to convert them to coal firing if sufficient volume is available for installation of the coal burning equipment and ash handling equipment. However, the cost of converting a fire-tube boiler to coal firing may be unsuitable, especially in small boilers.

4.3.2 Water-Tube Boilers

Because the utility of steel fire-tube boilers becomes limited as capacity and pressure requirements increase, water-tube boilers are usually used for pressures above 150 psi and capacities above 15,000 lb steam per hour. The steel water-tube boilers are of the horizontal straight-tube type or bent-tube type.

Until the development of the bent-tube type of water-tube boiler, the horizontal straight-tube boiler was used for the majority of industrial applications. As illustrated in Figure 57, the straight-tube boiler is made up of banks of tubes connected to headers. These tubes are inclined to promote circulation. A drum, arranged either horizontally or crossways with respect to the tube axes, is connected to the headers by circulation tubes.

Because it offers (1) greater economics in fabrication and operation through the use of welding, improved steels and waterwall construction, (2) greater accessibility for inspection, cleaning, and maintenance, and (3) the ability to operate at higher steaming rates and deliver drier steam, the bent-tube boiler has replaced the horizontal straight-tube boiler in modern boiler designs. The main elements of

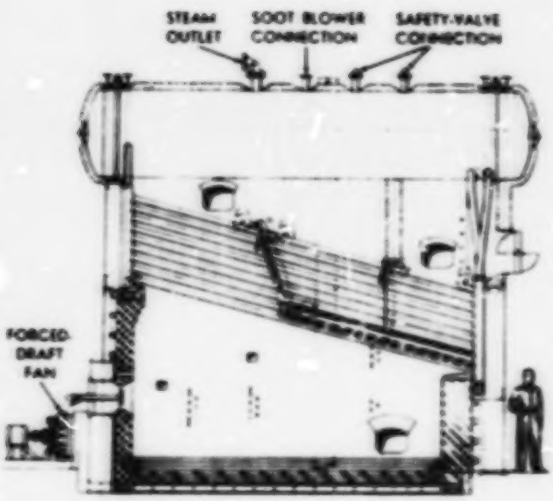
STEAM OUTLET
SOOT BLOWER CONNECTION
SAFETY-VALVE CONNECTION
FORCED-DRAFT FAN

Figure 57. Horizontal straight-tube boiler[68]

the bent-tube boiler are drums connected by bent tubes. In water cooled furnace designs, bent tubes are arranged to form the furance enclosure, making it integral with the boiler. The bent-tube boiler permits great flexibility in in design and permits free expansion and contraction. Three Babcock and Wilcox bent-tube boiler designs with a description of the capacities, steam temperatures, and pressures, fuels used and dimensions are shown in Figures 58 through 6.

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[68] p. 33.

4.3.3 Fouling Characteristics

In large water-tube boiler units, slagging is a major problem. The Bureau of Mines has conducted studies in a pilot plant test furnace to determine the relative fouling potentials of various coals.[70] The original program objective for these studies was to develop a correlation between the individual ash constituents and the rate of fouling in a test furnace, but it was difficult to determine the effect of small changes in ash composition because reproducible results were hard to obtain. The relative fouling potentials of coals having a wide range of moisture content, ash content, sulfur content, ash fusion temperature, and ash analysis were determined. The coal characteristics and fouling potentials are reproduced in Table 46.

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[70] Technology and Use of Lignite. Proceedings: Bureau of Mines; University of North Dakota Symposium. Elder, J. L. and W. R. Kube (ed). Grand Forks, North Dakota, May 1-2, 1969. Bureau of Mines Information Circular. 8471. 1970. pp. 69-88.

Table 46. SUMMARY DATA FROM ASH FOULING TESTS[70]

Sample[a]	No. of tests	Dry coal rate, lb/hr	Moisture content as-fired, percent	Coal analysis, dry basis: Volatile matter, percent	Fixed carbon, percent	Ash, percent	Sulfur, percent	Heating value Btu/lb	Ash fusibility, °F: IT	ST	FT	Coal ash analysis, percent: SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	CaO	MgO	Na_2O	K_2O	SO_3	Relative fouling potential[b]
									Lignite													
[illegible] Mine, [illegible] County, North Dakota																						
BN-1	2	[illegible]	31	41.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,120	21.[illegible]	15.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.6	[illegible]	12	Medium
BN-2	1	52.8	27	41.41	45.51	9.[illegible]	[illegible]	11,120	2,110	2,160	2,205	32.[illegible]	18.9	[illegible]	[illegible]	[illegible]	19.8	6.9	7.3	0.9	11.3	Medium
BN-3	2	47.6	28	41.35	41.08	8.97	[illegible]	10,390	2,170	2,165	2,210	29.3	19.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14.1	High
Baukol-Noonan Mine, Oliver County, North Dakota																						
C-1	2	53.5	35	[illegible]	[illegible]	7.31	0.76	10,950	2,415	2,450	2,490	[illegible]	[illegible]	11.1	[illegible]	[illegible]	27.9	5.9	1.9	0.3	19.9	Low
Beulah Mine, Mercer County, North Dakota																						
B-1	4	51.5	25	41.26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.9	[illegible]	0.4	0.1	[illegible]	5.7	1.1	0.3	[illegible]	Low
B-2	6	53.2	28	39.63	48.57	11.80	1.41	10,410	2,085	[illegible]	[illegible]	19.9	9.8	9.3	0.4	0.1	19.0	5.6	[illegible]	0.4	24.8	High
B-RL	[illegible]	53.7	35	41.81	47.75	10.56	1.31	10,760	[illegible]	[illegible]	2,165	15.9	11.5	[illegible]	0.6	[illegible]	[illegible]	[illegible]	[illegible]	0.4	[illegible]	Medium
B-STD	4	52.3	30	[illegible]	47.71	10.71	[illegible]	10,550	2,230	[illegible]	2,315	[illegible]	11.1	9.4	0.4	[illegible]	21.9	[illegible]	1.1	0.1	[illegible]	High
Peerless Mine, Bowman County, North Dakota																						
P-1	1	51.7	[illegible]	[illegible]	46.32	[illegible]	1.47	10,673	[illegible]	[illegible]	2,435	21.8	15.4	3.0	0.4	0.1	21.7	[illegible]	3.2	[illegible]	[illegible]	Medium
Glenharold Mine, Mercer County, North Dakota																						
GH-1	2	52.9	31	44.21	[illegible]	8.34	0.35	11,960	[illegible]	2,260	2,295	16.1	8.8	[illegible]	0.4	0.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Medium
GH-2	2	51.9	31	44.31	[illegible]	9.86	[illegible]	[illegible]	[illegible]	2,245	2,270	[illegible]	9.7	[illegible]	[illegible]	0.1	[illegible]	[illegible]	9.9	[illegible]	[illegible]	High
GH-3	2	52.7	30	43.69	44.93	11.31	0.75	10,530	2,115	2,195	2,175	[illegible]	12.1	[illegible]	[illegible]	0.1	17.0	4.5	[illegible]	[illegible]	[illegible]	"
GH-4	1	51.5	32	43.51	47.46	8.83	0.95	11,540	2,167	2,190	2,260	[illegible]	9.0	11.0	0.3	0.2	26.0	[illegible]	11.5	0.5	21.1	"
GH-5	2	51.8	27	44.28	46.07	8.64	0.76	10,840	2,055	[illegible]	2,165	17.1	11.6	9.1	0.4	0.2	21.6	6.2	9.5	0.8	17.8	"
Indian Head Mine, Mercer County, North Dakota																						
I-[illegible]	2	50.3	27	41.13	47.15	11.71	1.37	10,750	2,095	2,140	[illegible]	19.9	11.6	[illegible]	[illegible]	[illegible]	[illegible]	6.2	7.6	[illegible]	[illegible]	High
Velva Mine, Ward County, North Dakota																						
V-1	4	55.8	32	41.71	51.27	7.01	[illegible]	10,790	[illegible]	2,580	2,615	11.4	7.9	6.1	0.2	0.2	[illegible]	10.4	7.8	0.4	11.8	Low
V-2	3	58.1	29	38.37	50.22	11.41	0.24	10,100	[illegible]	2,385	2,424	33.1	18.7	[illegible]	0.5	0.1	[illegible]	6.2	2.8	0.2	[illegible]	Medium
V-3	2	56.9	31	40.96	[illegible]	8.55	0.33	10,580	2,455	[illegible]	2,525	[illegible]	10.1	6.6	0.6	[illegible]	[illegible]	3.5	1.8	0.1	9.8	Low
V-4	2	52.1	35	42.15	49.51	8.32	0.96	10,870	[illegible]	2,473	[illegible]	24.4	11.1	[illegible]	0.4	0.2	[illegible]	8.3	8.0	0.5	17.2	Low
Savage Mine, Richland County, Montana																						
S-1	1	53.9	34	40.98	[illegible]	[illegible]	[illegible]	[illegible]	2,250	[illegible]	2,350	[illegible]	11.0	10.0	[illegible]	[illegible]	22.7	[illegible]	[illegible]	0.1	[illegible]	Low
S-2	1	54.9	30	42.18	44.03	13.74	0.83	[illegible]	2,050	2,100	2,150	[illegible]	20.3	[illegible]	0.5	0.6	16.4	[illegible]	0.4	[illegible]	[illegible]	Low
Pike County, Alabama																						
ALA-1	1	48.6	43	42.11	42.40	15.48	4.01	10,130	[illegible]	2,300	2,350	27.6	20.7	4.1	[illegible]	0.1	[illegible]	10.1	0.1	[illegible]	[illegible]	Low
Rockdale, Texas																						
TEX-1	2	59.2	28	[illegible]	37.85	17.92	1.86	10,540	2,070	2,120	2,170	39.3	17.8	7.3	1.4	[illegible]	16.3	1.7	0.2	0.1	15.6	Medium
[illegible], Texas																						
TEX-2	2	49.9	[illegible]	44.80	[illegible]	8.02	0.75	11,390	2,095	2,185	2,185	25.5	14.1	11.9	1.0	0.1	[illegible]	[illegible]	0.9	[illegible]	19.2	Low

Table 46 (continued). SUMMARY DATA FROM ASH FOULING TESTS70

Sample^a	No. of tests	Dry coal rate, lb/hr	Moisture content as-fired, percent	Coal analysis, dry basis: Volatile matter, percent	Fixed carbon, percent	Ash, percent	Sulfur, percent	Heating value, Btu/lb	Ash fusibility, °F^b: IT	ST	FT	Coal ash analysis, percent: SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	CaO	MgO	Na_2O	K_2O	SO_3	Relative fouling potential^c
								Subbituminous Coal														
Centralia, Washington																						
CEN-1	3	58.6	17	41.69	45.69	12.61	0.57	11,240	2,250	2,300	2,350	46.2	25.7	6.1	3.7	1.1	9.6	1.5	0.5	0.7	5.2	(d)
Colstrip, Rosebud County, Montana																						
CS-1	2	47.4	21	39.86	50.40	9.74	0.86	11,620	2,190	2,220	2,250	35.4	19.0	5.6	0.8	0.1	17.3	4.9	[illegible]	0.1	16.1	Low
Glenrock, Wyoming																						
GR-1	3	49.2	22	45.03	49.59	5.38	0.82	11,115	2,120	2,155	2,190	33.5	15.7	5.4	0.6	0.4	25.5	3.7	0.3	0.5	16.4	Low
								Bituminous Coal														
Mine No. 10, Christian County, Illinois																						
ILL-1	2	56.1	17	39.73	43.74	16.53	4.99	11,510	1,975	1,985	1,985	41.7	17.0	21.1	0.9	0.1	7.0	1.0	1.5	1.8	6.1	Medium
River King Mine, St. Clair County, Illinois																						
ILL-2	2	51.7	8	37.05	42.55	20.41	5.37	11,130	1,965	2,030	2,150	41.6	17.6	19.[illegible]	0.9	0.4	6.1	2.2	[illegible]	1.6	3.8	Low
Sunnyside Mine, Carbon County, Utah																						
SU-1	2	41.6	4	39.90	54.06	6.05	0.74	11,863	2,445	2,500	2,550	59.3	[illegible]	4.5	1.1	1.7	4.6	[illegible]	1.1	1.1	2.5	Low
Arkwright Mine, Monongalia County, West Virginia																						
ARK-1	1	37.0	1	35.26	58.81	5.93	2.1	14,[illegible]	2,140	2,190	2,270	44.8	[illegible]	[illegible]	0.5	0.1	[illegible]	1.3	0.8	0.5	3.7	Low

[a] Spot samples, not necessarily representative of mine.

[b] Standard Method of Test for Fusibility of Coal and Coke Ash, ASTM Designation D 1857-68. Initial deformation temperature--IT, Softening temperature--ST, Fluid temperature--FT. ASTM Standards, Gaseous Fuels; Coal and Coke, Part 19, March 1969, American Society for Testing and Materials. Philadelphia, Pa., pp. 111-116.

[c] Based on weight of deposit collected on probe tube 1 during standard test:

Weight, grams	Rating
0-150	Low
150-300	Medium
Above 300	High

[d] During test ash built up on refractory duct walls and eventually bridged across tubes. Ash did not appear to bond much to the metal tubes.

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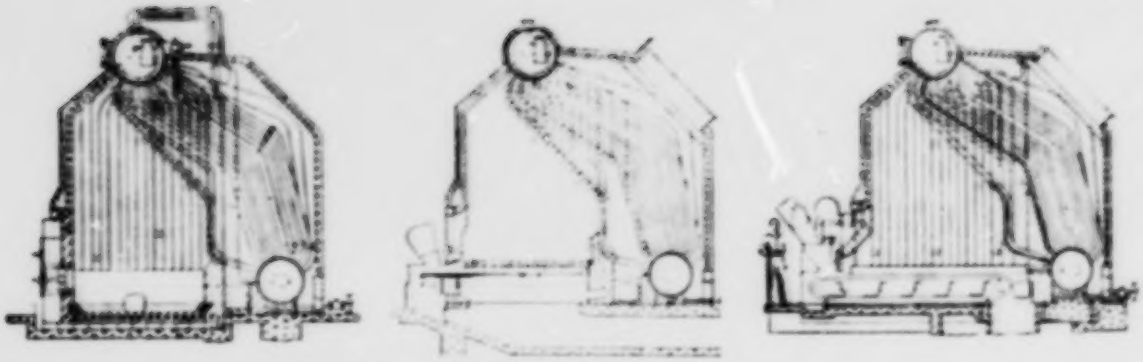
70 pp. 76-77.

Table 47. TYPICAL ASH COMPOSITION[a]
(wt-%)

State		% of Moisture-Free Coal Ash	% of Moisture-Free Coal Sulfur	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	P$_2$O$_5$	CaO	MgO	Na$_2$O	K$_2$O	SO$_3$
NORTHERN GREAT PLAINS PROVINCE													
Colorado	Min.	3.0	0.4	34.9	15.2	3.2	1.0	0.01	0.4	0.4	0.1	0.1	0.2
	Ave.	10.2	0.7	50.4	28.8	6.1	1.3	0.5	6.2	1.1	0.7	0.3	5.2
	Max.	19.2	1.1	71.8	39.2	11.9	1.7	2.8	12.8	2.9	3.0	0.8	15.1
Montana	Min.	4.2	0.4	21.9	13.8	2.9	0.6	0.02	1.8	1.4	0.1	0.3	2.4
	Ave.	12.6	0.6	35.4	21.5	6.1	0.8	[illegible]	13.4	4.6	2.8	0.7	13.3
	Max.	19.3	0.9	53.6	31.9	8.0	1.2	0.76	31.4	10.4	8.1	1.8	26.2
New Mexico	Min.	2.9	0.6	28.9	14.3	3.6	0.9	0.02	1.7	0.8	0.1	0.1	0.5
	Ave.	10.5	1.3	49.2	21.8	13.9	1.1	0.06	6.4	2.0	0.7	0.6	4.7
	Max.	16.3	3.2	61.5	30.0	27.3	1.3	0.12	14.0	4.2	2.2	1.1	17.3
North Dakota	Min.	7.5	0.5	15.0	8.0	4.1	0.6	0.04	14.5	3.3	0.5	0.1	16.6
	Ave.	11.8	1.0	26.3	12.1	6.9	0.7	0.2	21.1	6.4	4.4	0.3	20.6
	Max.	16.9	1.5	40.4	16.8	10.1	0.9	0.42	36.0	10.8	8.2	0.6	27.4
Utah	Min.	5.7	0.4	39.4	9.1	3.7	0.6	0.03	3.5	0.3	0.4	0.1	1.8
	Ave.	7.7	0.8	51.4	15.1	7.4	1.0	0.6	11.8	2.3	1.7	0.6	6.0
	Max.	9.6	2.2	63.2	20.3	19.3	1.3	1.4	21.9	7.6	4.3	1.4	9.6
Wyoming	Min.	6.4	0.6	24.5	14.2	9.0	0.3	0.21	9.4	4.4	0.1	0.5	14.4
	Ave.	10.4	1.2	31.5	16.9	9.6	1.3	0.36	20.1	4.5	0.1	0.5	15.2
	Max.	14.4	1.8	38.6	19.6	10.3	1.8	0.51	30.8	4.7	0.2	0.6	16.1
COAST PROVINCE													
Washington	Min.	6.1	0.4	37.2	29.7	2.8	1.2	0.18	1.7	0.9	0.2	0.6	1.0
	Ave.	10.6	0.5	45.9	33.5	5.6	2.3	1.7	3.1	1.5	0.7	1.1	3.6
	Max.	22.4	0.5	54.1	39.2	9.2	4.7	2.6	7.6	2.6	1.3	1.7	10.5

[a] reproduced from Table 28



GENERAL COMMENTS

The FF Integral-Furnace boiler is one of the well-standardized types of widely used in industrial plants. With suitable firing methods, oil fuel varying in characteristics from bunker C to residual and bituminous coals of a wide range in percent ash and fusion temperature may be burned successfully. Pulverized-coal firing is not used for this unit.

The range in vertical height of unit (a series of 5 standard dimensions between upper and lower drums), which in turn affects the other two dimensions, permits a size selection for comparable performance to suit many existing space conditions of headroom and floor area. The space conditions required for either spreader-stoker or chain-grate firing are comparable.

No major changes in the boiler unit are involved in converting from oil and gas to coal firing or the reverse. The "saturated" surface components are generally not affected. There are minor alterations to brickwork to suit the new firing equipment, and if a superheater is present, it may be necessary to add or remove some surface to meet changed combustion requirements (chiefly excess air) of the new fuel.

When fuel saving justifies the expenditure, economizers and air heaters may be added, as in most boiler types, to utilize low-level heat. However, of the more than 1500 type FF boilers placed in service in the period 1940-1960, less than 10 percent were equipped with air heaters or economizers. The proportion of boilers equipped with these additional heat traps will tend to increase as fuel prices rise.

Figure 58. Type FF integral-furnace boiler[69]

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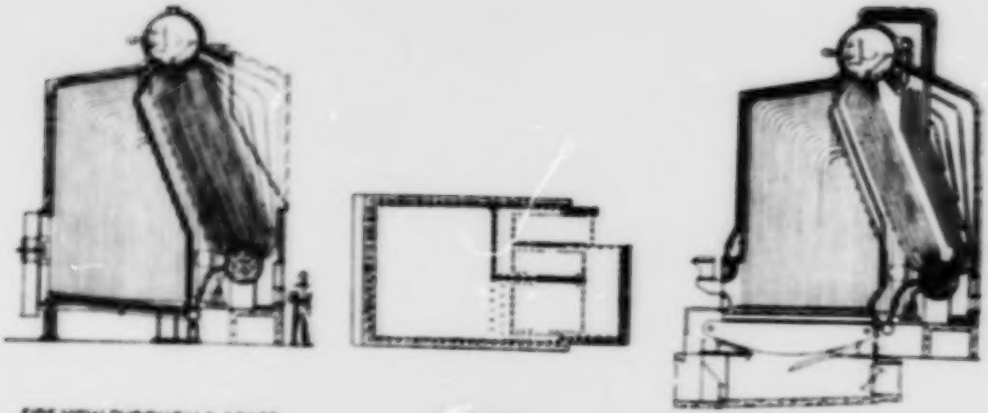
[69] Anon. Steam/Its Generation and Use. 37th Edition. New York, Babcock and Wilcox Company, 1963. p. 23-13.



SIDE VIEW THROUGH 3rd PASS.
OIL & GAS FIRED

PLAN VIEW

SIDE VIEW THROUGH 1st PASS.
SPREADER-STOKER FIRED

GENERAL COMMENTS

The FP Integral-Furnace boiler is particularly well suited for stoker firing. With its completely water-cooled furnace, the rates of heat input and heat absorption may be somewhat higher than for the type FP boiler. Travel of the gas through the boiler has been arranged so that the abrasive particles are not concentrated in streams.

Oil and gas firing, either singly or in combination, is entirely suitable and may be used initially as an alternate to stoker firing. Permanent conversion from one fuel to another is as simple for the type FP boiler. Installation of oil and gas burners in the side walls of a stoker-fired unit permits combination firing, either simultaneously with coal or separately. When firing oil and gas alone, the stoker must be protected with a suitable tile or ash coating. The unit is not designed for pulverized-coal firing. If the fuel saving justifies the expenditure, economizers or air heaters should be installed.

The type FP boiler is well suited for the production of steam for both industrial and power requirements. A highly trained operating staff is not required for its successful operation.

Figure 59. Type FP integral-furnace boiler[69]

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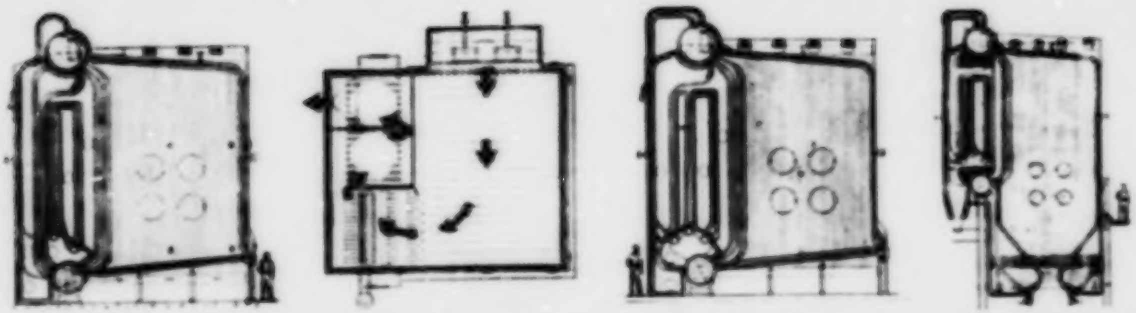
[69] p. 23-14.



SECTIONAL SIDE VIEW, OIL AND GAS FIRED

PLAN CROSS SECTION SHOWING HORIZONTAL GAS FLOW PATH

SECTIONAL SIDE VIEW, PULVERIZED-COAL FIRED FLAT FLOOR FOR ASH RAKE-OUT

SECTIONAL SIDE VIEW, PULVERIZED-COAL FIRED WITH ASH HOPPER

GENERAL COMMENTS

The FH Integral-Furnace boiler is particularly well suited for pulverized-coal firing and is widely used for maximum outputs from 50,000 to 350,000 lb of steam per hr. With its furnace construction of touching tubes, except for refractory areas around the burners, it is designed for moderately high-duty service. Heat liberation rates may be correspondingly high per sq ft of furnace area per hr for a coal ash-softening temperature of 2500°F, oxidizing basis, with rates reduced for lower ash-softening temperatures. The allowable heat liberation rates are generally lower for the flat-floor than for the hopper-bottom arrangement.

Standard superheaters, both inverted and pendent types, are available to suit the specific application. Where constant steam temperature is required over a considerable load range, an attemperator is installed in the lower drum. Air heaters are invariably necessary to provide hot air for drying the coal and as an aid in combustion, they are also usually justified by the fuel saving. With high fuel costs, economizers are also sometimes justified.

Figure 60. Type FH integral-furnace boiler[69]

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[69] p. 23-16.

The ash sodium content appeared to have the greatest effect on the fouling rate. The fouling rate was found to increase rapidly with increasing sodium content at low sodium contents. It leveled off, however, at 8 to 10% sodium content. It was also found that high calcium content reduces the effect of sodium on the deposition mechanism. The coal ash composition ranges given in Table 47 show that North Dakota and Montana coals have ashes containing the largest quantities of sodium. Wyoming coals appear to have the lowest sodium content suggesting that they are less prone to fouling.

Other factors affecting the ash fouling rate, which were also studied by these authors, include the percentage of excess air, tube metal temperature, fuel moisture content and gas temperature at the probe bank. It was found that no significant effects on fouling rate were produced by changes in the fuel moisture content or the percentage of excess air. An increase in the fouling rate was observed as the probe metal temperature was increased from 800°F to 1200F°. When the flue gas temperature was increased from 1800°F to 2100°F, a similar increase in fouling rate was observed. Various chemical additives were studied as a means of reducing deposition rate and deposit strength, but no additive was as effective as reducing the sodium content from 6 to 1%.

Reid points out the fact that the properties of the coal ash mainly affect the way in which the coal is burned.[70] He also states that the significant factors related to the coal ash are its fusibility, which establishes limits for temperature during and after combustion, and its contribution of chemical reactants that lead to external corrosion of heat-receiving surfaces exposed to the products of combustion.

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[70] pp. 38-51.

The problem of clinkering is related to the ash softening temperature, and coals may be placed into four broad categories based on softening temperature as shown in Table 48: low fusion, moderate fusion, high fusion, and refractory (although fuels technologists may disagree on the limits of the classes). The inorganic matter in coal which is responsible for external corrosion of superheaters and reheaters is composed of alkalies and sulfur. Garner[71] has developed an equation by the use of regression analysis which relates the fouling tendency of Australian brown coals to the percentages of SiO_2, Fe_2O_3, CaO, MgO and Na_2O in the ash. Again, sodium was found to be the major factor in fouling rate.

Table 48. COAL ASH CLASSIFICATION[70]

	Range, °F
Low fusion	1800-2100
Moderate fusion	2100-2400
High fusion	2400-2700
Refractory	2700-3000

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[71] Garner, L. J. The Formation of Boiler Deposits from the Combustion of Victorian Brown Coals. J. Inst. Fuel. 40(314):109-116, 1967.

[70] p. 40.

4.3.4 Corrosion of Boiler Tubes

The processes involved in external corrosion have been summarized by Reid as follows:[70]

1. Sodium and potassium are volatilized in part from ash constituents in the 3000°F flame.
2. Pyrites are dissociated thermally, and with the organic sulfur in the coal, provide 2000 to 3000 ppm SO_2 in the flue gas.
3. About 1 percent of the sulfur in the coal appears in the flue gas as SO_3 by reaction of SO_2 with oxygen atoms present in the flame.
4. The volatilized sodium and potassium thus are converted at least in part to the sulfates, and, with the unconverted oxides, deposited on the relatively cool metal surfaces where the sulfation reactions continue, ending up with a thin layer of Na_2SO_4 and K_2SO_4 on the Fe_2O_3 outer layer of the oxide scale.
5. Ash particles are captured by this sulfate layer and eventually a moderately thick layer of ash builds up on the tube surface.
6. Sulfur dioxide present in the flue gas reaches the interface between Fe_2O_3 and the alkali sulfates, and in the presence of excess O_2, oxidizes to SO_3 on the catalytic Fe_2O_3 surface. Apparently this reaction reaches near-equilibrium levels of SO_3, and almost certainly it is responsible for a concentration as high as 1000 ppm of SO_3.

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[70] pp. 50-51.

7. At such high concentrations of SO_3, reactions occur with the Fe_2O_3 and the alkali sulfates to form $Na_3Fe(SO_4)_3$ or $K_3Fe(SO_4)_3$, which are molten at about 1100°F in a high-SO_3 atmosphere.
8. These molten trisulfates can provide an electrolyte for further corrosion by galvanic action, but essentially they remove the adherent outer layer of Fe_2O_3 always present on tube scale, so that the tube oxidizes further to replace its normal scale at that temperature.

The major argument against this mechanism is that the trisulfates may be formed, not by reaction between SO_3 and alkali sulfates with the Fe_2O_3 on the tube surface, but with the Fe_2O_3 present in the ash deposited on the tube. The resulting trisulfates are then thought to migrate to the tube surface along the temperature gradient existing in the deposit. At the tube surface, the trisulfates would react with iron, causing wastage.

The reactions are as follows, with potassium behaving similarly:

$$3Na_2SO_4 + Fe_2O_3 + 3SO_3 \rightleftarrows 2Na_3Fe(SO_4)_3 \qquad (2)$$

$$10Fe + 2Na_3Fe(SO_4)_3 \rightleftarrows 3Fe_3O_4 + 3FeS + 3Na_2SO_4 \qquad (3)$$

Reaction 2 proceeds whether the source of the Fe_2O_3 is the tube scale or the ash deposit. Reaction 3, which can only occur if the trisulfates have been formed first in the ash deposit, will take place only if metallic iron is in contact with the trisulfate. It is difficult to see how this can be, since no iron is ever exposed at these temperatures, only an oxide scale; no reaction has been identified between iron oxides and the trisulfates. Nevertheless, the fact that reaction 3 does occur at least occasionally is shown by the presence of small amounts of FeS at times in corrosion areas. This is possibly explainable by cracks or imperfections in the oxide scale exposing elemental Fe.

Whichever mechanism predominates, it is evident that coal ash, other than supplying the needed alkalies and sulfur, takes part in corrosion mainly by supplying the proper environment for the formation of SO_3 at a high enough level to form the trisulfates.

4.4 WESTERN COAL COMBUSTION

Holyoak has described some of the problems associated with burning western low sulfur coals in equipment designed to burn midwestern coals.[72] Some of the characteristics of the coals used in the study are given in Table 49. The problems described include dust formation, a reduction in boiler capacity, different slagging characteristics, a reduction in electrostatic precipitator efficiency and ash handling problems.

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[72] Holyoak, R. H. Burning Western Coals in Northern Illinois. (Paper presented to the Fuels Division of the American Society of Mechanical Engineers at the Winter Annual Meeting, Detroit, Michigan, November 11-15, 1973.) pp. 1-9.

Table 49. COMPARISON OF WESTERN COAL AND TYPICAL ILLINOIS COAL[72]

Property	Mine and state				
	Colstrip Montana	Arch Mineral #1 Wyoming	Arch Mineral #2 Wyoming	Decker Montana	? Illinois
Sulfur, %	0.65	0.38	0.33	0.31	3.5
Heating value, Btu/lb	8,630	9,770	10,590	9,640	10,600
% Reduction Btu compared to Illinois	18	8	0	9	-
Moisture, %	26	14	14	23	17

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[72] p. 3.

The western coals used in Holyoak's study were friable and broke easily on impact. This caused the production of a considerable amount of fines during the 1200-mile train trip to the utility stations where the tests were conducted. Although the Arch Mineral coal received about 1.5 gallons of oil per ton of coal at the mines, dust problems were great enough to require the installation of special dust control equipment for use of western coals.

The decrease in boiler capacity for western coal, compared with the coal for which the equipment was designed, was caused by the reduced coal conveyor belt capacity due to the lower density of the western coals and by the reduced pulverizer mill capacity due to the coal's lower heating value. The reduced grindability of the Decker and Colstrip coals, caused by high moisture content, further reduced the pulverizer mill capacity because of the increased coal recirculation within the mill. The mill capacity was improved somewhat by increasing the mill feeder capacity. Wet western coal fines were found to plug feeder chutes more than wet Illinois coal fines. No change in pulverizer maintenance was reported.

Differences in slagging characteristics were rated in Holyoak's study. Burning low sodium western coal caused very low slagging of the wall and superheater sections of the boiler compared with slagging when Illinois coal was burned. However, the resulting increased heat transfer rate increased the rate of scale buildup on the water side of the heat exchange surfaces. The acid tube cleaning procedures were increased from 5-year to 3-year intervals to correct the problem. When high sodium coal such as Decker coal was burned in a pulverized coal boiler, increased fouling rates were encountered. It was found that the deposits could be easily removed by increasing the soot-blowing frequency and pressure. Additional sootblowers were needed in only one case.

The decrease in collection efficiency of electrostatic precipitators (ESP's) in installations burning low-sulfur coal is a well known fact. The efficiency decrease is generally thought to be caused by high flyash resistivity of certain low sulfur coals. The flyash resistivity characteristics for coals with varying sulfur content between temperatures of 200 and 450°F are shown in Figure 61. The flyash resistivity is shown to be most strongly affected by temperature as the coal sulfur content decreases. For this reason the operation of ESP's in a "hot" temperature mode can increase the efficiency to normal levels (95%$^+$).

Resistivity of flyash is not affected solely by sulfur content in the fuel. It is a function of interacting variables such as temperature, composition, surface phenomena, etc. One recent significant discovery was the positive correlation of resistivity to sodium content in flyash. Figure 62 shows data obtained for a group of western power plants. An increase in sodium concentration in flyash decreased the resistivity of the flyash and made the efficient collection possible with certain low-sulfur western coals.[73] This discovery may lead to the possible incorporation of sodium injection flyash conditioning as an effective method of increasing ESP collection efficiencies for low-sulfur, low-sodium coal burning installations.

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[73] p. 34.

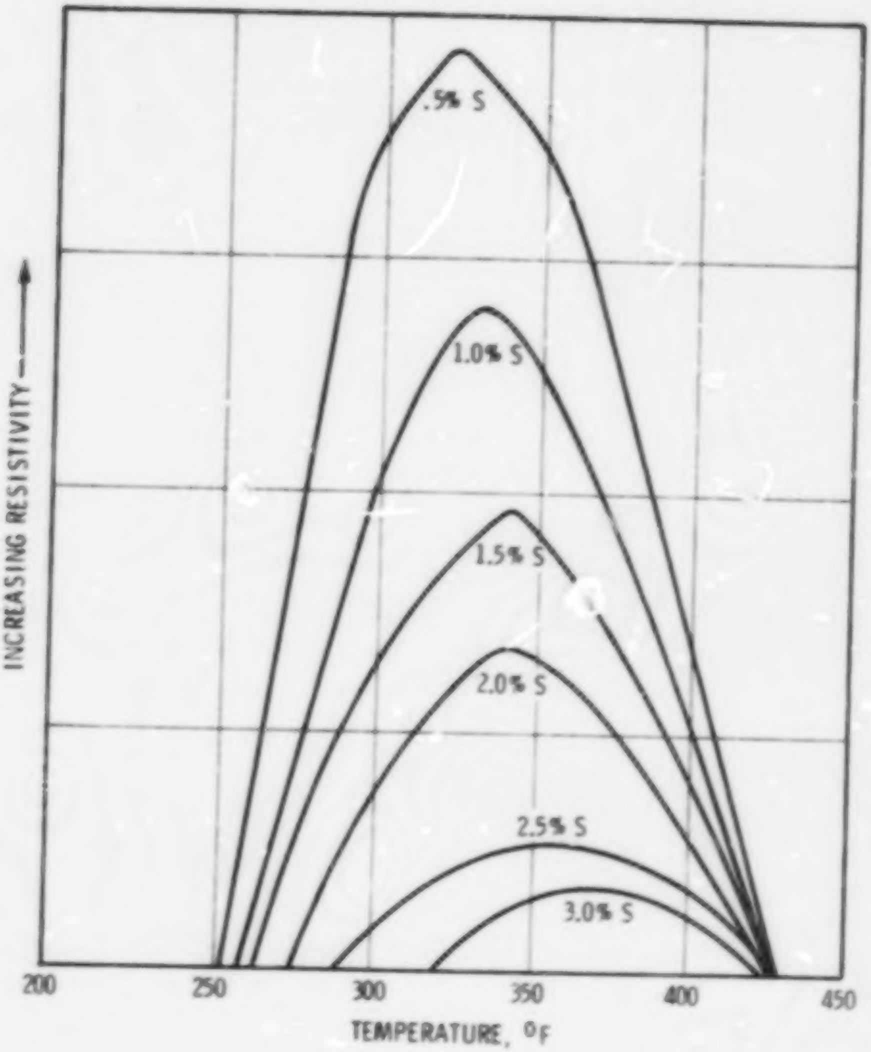

Figure 61. Fly ash resistivity as a function of temperature and coal sulfur content[72]

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[72] p. 8.

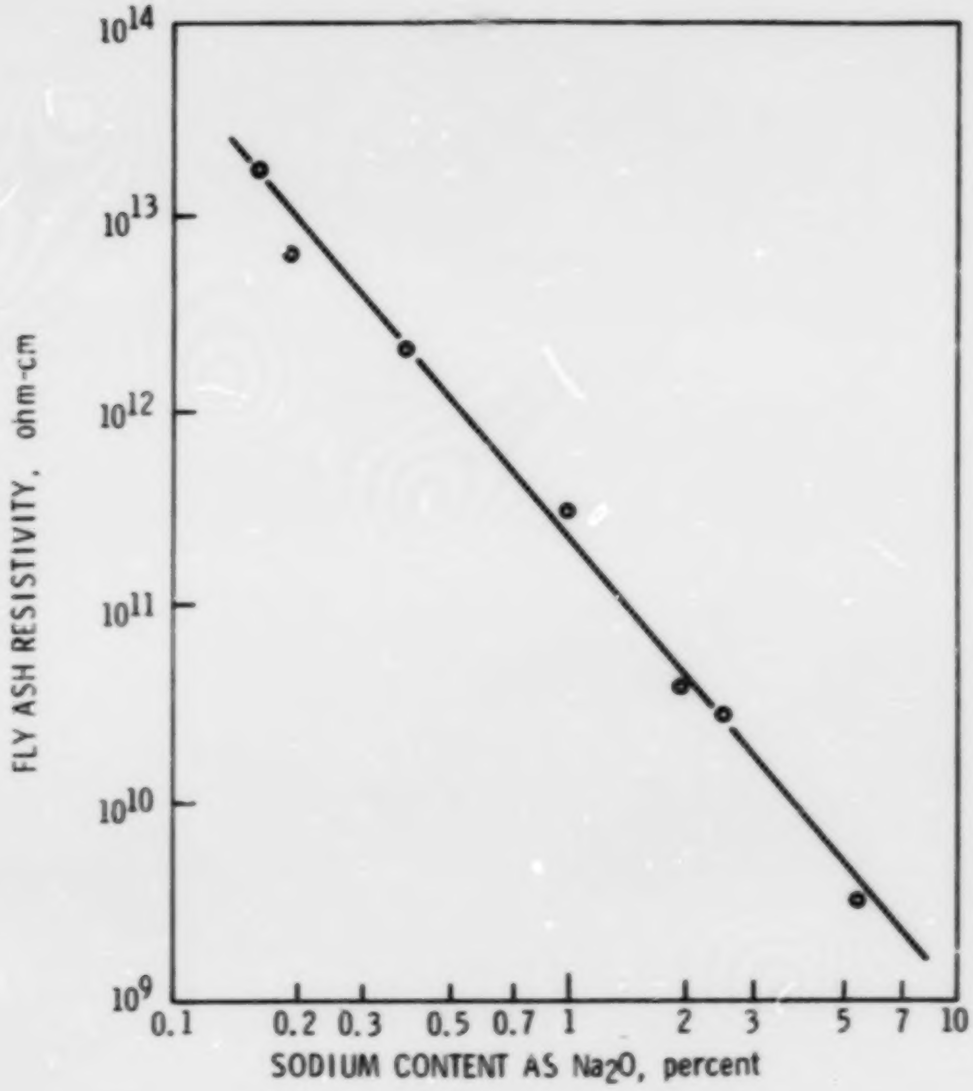

Figure 62. Resistivity as function of sodium content of the fly ash for a group of western power plants[73]

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[73] White, H. J. Resistivity Problems in Electrostatic Precipitation. Journal of the Air Pollution Control Association. 24(4):334, April 1974.

Although the ashes from the western coals used in Holyoak's study were easily sluiced, they had a fine consistency and were difficult to dewater.[72] These western coals also have ash with high calcium content which readily dissolves in water. This gave higher dissolved solids content to water treatment plant effluents. The high calcium oxide content of the western coal flyash with its affinity for water causes the sluiced flyash to flow less easily (higher viscosity) and to set up and harden easily after dewatering. For western coal flyash Holyoak recommended that the dust handling system be larger or be modified to keep the dust hotter within the collection device.

The TVA conducted tests at the Johnsonville steam plant on the burning of low sulfur Montana coal.[74] The two steam generation units tested were a corner-fired pulverized coal Combustion-Engineering boiler designed to produce 1,000,000 pounds steam per hour and a rearwall-fired pulverized coal Foster Wheeler reheat steam generator of 1,100,000 pounds steam per hour capacity. The fuels used in these tests were Montana coals with 27.5% moisture, 1.6% sulfur (dry basis), and a heating value of 7865 to 8999 Btu per pound (as fired), and Kentucky coals with 10% moisture, 3.3% sulfur (dry basis), and heating value of 9975 to 10416 Btu per pound (as fired).

A 35.5% reduction in generating capacity was observed when burning low sulfur Montana coal in the Foster Wheeler unit, compared with the performance of Kentucky coal. With the

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[72] p. 6.

[74] McKinney, W. Tennessee Valley Authority, Division of Power Production. Personal Communication.

Combustion Engineering unit, a 15% reduction in generating capacity was observed. The reductions resulted from the inability of the coal feeder-pulverizer-exhauster systems to handle the increased quantity of low heating value coal.

The TVA tests also reported that the higher moisture content of Montana coal caused a loss in boiler efficiency due to higher heat loss up the stack (about 2.5% higher loss). The heat loss results from utilization of boiler heat to supply the latent heat of vaporization to vaporize moisture in coal. The total carbon loss (Section 4.1) up the stack for Montana coal was found to be lower than for Kentucky coal. Furnace slagging was reduced when Montana coal was burned.

It thus appears that the conversion of existing high sulfur power plants to low-sulfur western coals is not a simple matter. The overall difference in burning this fuel lies in the inherent problem of operating the plant outside of its designed operating limits. The operating parameters which were affected by western coal's characteristics are summarized below. These factors must be considered prior to large scale conversion to western coal.

1. Excessive dusting of coal en route to power plant.
2. Reduced conveyor belt capacity.
3. Decreased pulverizer output (if so equipped).
4. Loss of boiler efficiency.
5. Water side scale buildup due to decreased slagging.
6. Increased fouling with high sodium coal.

7. Decreased ESP efficiency when low sodium coals are utilized necessitating hot ESP operation; injection of sodium or other resistivity decreasing chemicals may be needed.
8. Ash dewatering difficulty and caking.
9. Increased sluiced ash viscosity.
10. Larger dust handling system requirements.

SECTION 5

ENVIRONMENTAL EVALUATION OF WESTERN COAL MINING AND UTILIZATION

The dramatic escalation in the mining and utilization of low sulfur western coal deposits has created much concern for the environment. Development of mining western coal must be accomplished with a minimum of adverse effects on the environment. The long-term effects of widespread surface and underground mining on the environment are not well defined or characterized in this arid and semi-arid region.

A recent study on coal energy development in three northern Great Plains states (Wyoming, Montana, and North Dakota) provides an excellent summary of environmental areas that need additional definition, as outlined in Table 50. It should be noted that these study areas apply equally to all western coal states.

This section identifies potential hazards to the western environment as a result of coal mining. Hazards discussed include land disturbance as a result of strip mining, revegetation and recontouring problems of reclamation, and coal refuse disposal. The effects of western coal trace elements on the environment are briefly discussed. Lastly the sulfur emission characteristics of western coals are discussed in relation to small and intermediate size boilers. A relationship is presented which can serve as a guide when choosing a western coal to meet the SO_x emission standard.

Table 50. STUDY NEEDS, COAL INDUSTRY DEVELOPMENT, NORTHERN GREAT PLAINS[75]
(tentative)

	High Priority
A. TRACE ELEMENTS	
1. Baseline studies of trace elements	Wyo., Mont.
2. Trace elements in regional coals	Wyo., Mont.
3. Trace elements & inorganics in coal by-products	3 states
B. ATMOSPHERIC EFFECTS	
1. Air quality management systems	Montana
2. Air quality baselines and air shed dynamics	3 states
3. Atmospheric mobilization of combustion factors	Mont., N. D.
4. Atmospheric effects by diffusion modeling	Mont., N. D.
C. COAL RESOURCES AND MINING TECHNIQUES	
1. Identify strippable coal deposits	3 states
2. Appraise strip mining techniques	3 states
3. Waste disposal	3 states
D. SURFACE RESOURCES	
1. Surface resources threatened by coal development	Mont., N. D.
2. Land use alternatives	3 states
3. Interpretative geological analysis	3 states
4. Coal development & biological ecosystems	3 states
E. SURFACE RESOURCES (RECLAMATION)	
1. Reclamation and land use options	Wyo., N. D.
2. Methods for mining & handling spoil banks	Wyo., N. D.

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[75] Anon. Water Resources Research Institutes of Wyoming, Montana and North Dakota. Coal-Energy Development in the Northern Great Plains. Laramie, Wyoming. NTIS Publication P.B-231560, October 1973. pp. 1-114.

Table 50 (continued). STUDY NEEDS, COAL INDUSTRY DEVELOPMENT, NORTHERN GREAT PLAINS[75]
(tentative)

	High Priority
3. Soil, water & revegetation programs	3 states
4. Combination of plants for revegetation	3 states
5. Propagation & cultivation of native plants	Montana
6. Clearing house for mine site revegetation	3 states
F. WATER RESOURCES	
1. Computer models for water planning	Wyo., Mont.
2. Water availability	N. D.
3. Water requirements and options	Wyo., N. D.
4. Ground water potential	3 states
5. Instream values of water	Wyo., Mont.
6. Effects of strip mining on wells	Mont., N. D.
7. Multiple use options for water systems	3 states
8. Recreational values for water options	3 states
G. WATER QUALITY	
1. Water quality data evaluation	3 states
2. Hydrology of development sites	3 states
3. Effects of coal industry on water quality	3 states
4. Effects of strip mining on aquifers	3 states
5. Salinity changes & downstream effects	Mont., N. D.
H. GENERAL TECHNOLOGY DEVELOPMENT & OTHER	
1. Technologies for conservation of energy	3 states
2. Waste heat reduction & water consertion in power plants	3 states
3. Improved stack emission control	Wyo., Mont.
4. Water saving technologies vs. water development	Wyo., Mont.

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[75] pp. 1-114.

5.1 ENVIRONMENTAL ASPECTS OF MINING

Land area disturbed by surface coal mining may be used as an indicator of environmental impact. Potential land disturbances for 14 states resulting from strip mining are shown in Table 51.

The potential land disturbance L (%) is defined as follows:

$$L = \frac{\left(A_P + A_R\right)}{A_S} \times 100 \qquad (4)$$

where A_P = square miles of state coal land previously disturbed (1930-1971)

A_R = square miles of land disturbed if remaining strippable reserves are entirely recovered

A_S = total square miles of state area

The land area previously disturbed by strip mining, A_P, was obtained from data of Paone et al.[76] The figures compiled in this report are for the period between the years of 1930 and 1971. The remaining area, A_R, was computed by the following relation:

$$A_R = \frac{0.072}{\rho} \sum_{i=1}^{n} \frac{W_i}{h_i} \qquad (5)$$

where W_i = tonnage recoverable from individual deposit

ρ = assumed coal density (84.2 lb/ft^3)

h_i = average coal seam thickness in feet

n = number of individual deposits per state

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[76] Paone, J., J. L. Morning, and L. Giorgetti. Land Utilization and Reclamation in the Mining Industry, 1930-71. Bureau of Mines Information Circular. 8642. 1974. pp. 11-61.

Table 51. POTENTIAL LAND DISTURBANCE IN THE WESTERN STATES AND SELECTED NON-WESTERN STATES

State	Total land area A_s (sq mi)	1968 total land underlain by remaining strippable coal reserves A_R (sq mi)[a]	Million tons per square mile remaining	Coal land previously disturbed (1930-1971) A_p (sq mi)	Potential disturbance by surface coal mining[b] L (%)
Arizona	113563	33.0	11.7	0.34	0.03
Colorado	103797	35.1	14.2	13.5	0.05
Montana	145603	312.3	22.1	10.6	0.22
New Mexico	121445	196.8	12.6	12.9	0.17
North Dakota	69280	127.8	16.2	42.5	0.25
Oregon	96209	0.06	4.9	0.03	9.3×10^{-5}
South Dakota	75956	27.3	5.9	0.48	0.04
Utah	82381	11.6	12.9	5.03	0.02
Washington	66663	5.21	25.9	2.1	0.01
Wyoming	97281	232.2	60.2	15.8	0.25
Total West	972178	981.4	—	103.3	0.11
Illinois	55877	776.4	4.2	365.6	2.04
Kentucky	39851	188.1	4.2	328.1	1.29
Ohio	41018	230.5	4.5	323.4	1.35
West Virginia	24084	443.0	4.8	306.2	3.11

[a] Does not account for land disturbed prior to 1968.

[b] Total disturbed land area after all presently known deposits are mined out.

Data for equation (5), W_i and h_i, were supplied from a Bureau of Mines report which presented strippable coal reserves remaining in the ground as of 1968.[2] The seam tonnage and average seam thickness were used to calculate remaining land disturbance for each state in Table 51. The following assumptions were made:

a) All of the coal deposits lie flat (horizontally) in the ground

b) All of the coal is eventually recovered by mining

The only data available to check equation (5) were from Wyoming with a reported A_R of 235.5 square miles.[19] The computed A_R is 232.2 square miles. It is not known how the reported figure was derived.

The 3-year period between 1968 and 1971 is not accounted for in land disturbance due to lack of available data. Additionally, the estimates of recoverable tonnage per seam, W_i, are thought to be very conservative judging from the updated figures published for some of the seams in more recent reports. Thus, the land disturbances, L, presented in Table 51 should be regarded as relative and should be corrected whenever new and more accurate data become available.

Several observations nonetheless, can be extracted from Table 51. It appears that potential land disturbance in the West is minimal from a percent-of-area disturbance standpoint when compared to non-western locations. The coal seams in the western areas are thick as seen from the tonnages per square mile. Wyoming appears to be the most difficult state to reclaim to original contours because of the "crater effect" of deep open pits. The difficulties lie in the depletion of fill material for these pits in flat regions. The potential land disturbance figures as calculated above do not account for future disposal of waste from surface stripping or for waste from underground mining.

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[2] pp. 70-121.

[19] p. 125.

The heterogeneous overburden mix produced by conventional strip methods can lead to revegetation problems in the West and Southwest. Displacement of surface soils by highly saline materials from under the surface in some areas makes vegetation growth difficult. Rainfall would displace these materials eventually, but this can take hundreds of years in the arid portions of the West.

One method of surface mining recently proposed would minimize deep open pits and not disturb fragile top soil structure. This is longwall stripping, a promising new surface mining concept. It adapts existing underground longwall mining technology for use in recovering shallow cover coal without the total environmental disturbance often associated with surface mining. A recent EPA sponsored study investigated the environmental, mining and economic feasibility of longwall stripping.[77] This method was determined to be feasible for mining coal under shallow cover for selected overburden structure as described in Section 3.2.1. Longwall mining calls for controlled caving of the mined out area as mining progresses. Surface caving is much less damaging environmentally than removal and relocation of overburden used in conventional stripping.

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[77] Anon. Environmental Pollution and Control. NTIS Weekly Government Abstracts. p. 363, August 19, 1974.

Full reclamation of land can minimize the damages to the environment. Full reclamation as is called for in proposed legislation consists of returning the land to near original contours with best soil materials on top. Toxic substances including acid-forming materials must be deeply buried. If siltation due to erosion can occur, water catch basins must be provided. The land must be managed for a period of years to restore nutrient and humus levels of the soil. Vegetation proven to be adaptable to a particular area must be planted and maintained. Some recent success on a laboratory scale has been obtained using mountain rye, fourwing saltbush and western wheatgrass in New Mexico.[78,79] The sparse vegetation present originally indicates that many years must pass before revegetation can be considered successful on a large scale.

Full reclamation is expensive. Recent estimates made on the Appalachain region appear to be of the order of $1500 to $4000 per acre.[33] Requirements include backfill, topsoil replacement and revegetation. Costs to fully reclaim western pits are expected to be higher because of the substantial quantity of additional earth needed to fill the pits after the coal is removed. The Black Mesa mine transports coal ash back to the Arizona mine from the Mohave

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[78] Aldon, E. F., O. D. Knipe, and G. Garcia. Revegetating Devastated Sites in New Mexico with Western Wheatgrass Transplants. Rocky Mountain Forest and Range Experiment Station. Research Note RM-243. June 1973. p. 3.

[79] Aldon, E. F., and H. W. Springfield. Revegetating Coal Mine Spoils in New Mexico. Rocky Mountain Forest and Range Experiment Station. Research Note RM-245. June 1973. p. 4.

[33] p. 24.

power plant to minimize contour damage. The Cholla power plant in Arizona routinely ships ash back to the Navajo mine in New Mexico. Non-toxic solid waste materials from midwestern coal destinations have been proposed as fill material for the coal pits of Wyoming. It has also been brought out that it is impossible to ever reclaim large strip areas to original contours because fill dirt would have to be stripped from non-coal regions to fill the huge western pits. Clearly, this problem needs further definition.

There are examples of successful reclamation in the West. One of these is the Big Horn coal mine in Sheridan, Wyoming.[80] This area is classified as semi-arid with 15 to 16 inches of precipitation annually. The spoil piles were graded to a rolling topography and care was taken to restore the original topsoil. Revegetation techniques used were fertilization sprinkling and the use of native tree seedlings and imports that thrive in arid climates. Water impounded in worked out areas is considered valuable since it does not become acidic (because it is mostly groundwater which tends to flow rather than stagnate). The low sulfur coal seams also tend to alleviate acid water buildup. The original topsoil needed to sustain growth is exceedingly thin in this area, running from two to six inches, and attempts to put soil back in its original state were difficult in some instances. Reclaimed spoil material was allowed to weather for one or two years in order to develop a surface that would permit germination of seed. Rye, oats and pasture-mix seeds were planted with success following artifical irrigation. Caragana and Russian olive seedlings were included in the planting. All varieties of seedlings had a high percentage of recovery.

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[80] Rulli, J. F. Reclamation at Big Horn Mine. Mining Congress Journal 57:42, June 1971.

The Black Mesa mine in Arizona has not been as successful.[81] Unsuccessful revegetation appears to characterize this arid region. Mined land is being acceptably regraded but little success is reported on revegetation due to comparatively little research on the general problem of mined land reclamation in this area. The Navajo mine in New Mexico near Four Corners also has not effected acceptable recontouring or acceptable reseeding according to the Department of Interior.[81]

Reclamation and revegetation in the West are clearly of a different nature than in the interior or eastern provinces. Mountainous eastern regions are difficult to recontour because of excessive slopes. Areas of Ohio and Illinois are less difficult to return to original contours because of thinner coal seams than those found in some areas in the West. Vegetation generally grows well in these non-western regions.

The strip mining process itself can have an adverse effect on the environment. Particulates and gases resulting from coal mining and related operations stem from several major sources. Nuisance particulates, coal dust, and silica-containing dusts originate from the following sources:

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[81] Bishop, F. 'Environmentalism' - Creating Crunch on Coal Industry. Mining Congress Journal. 59:111, February 1973.

1. Haul roads
2. Drilling and blasting operations
3. Open rail car shipments to market
4. Reclamation operations and overburden handling
5. All coal handling and storage at mine site
6. Thermal dryers and air cleaning operations
7. Wind erosion

These sources are not well defined from an air emissions standpoint. Extensive efforts now underway will characterize these emissions and determine areas where control technology is needed to prevent hazards to the general environment.

Roughly 21% of total western coal produced is currently sent to some form of cleaning operation (Section 3.2.2). A survey taken in 1968 showed that in Washington, Oregon and Montana alone, 805 acres of land were covered with coal cleaning waste in the form of refuse piles.[82] This amounted to over 36 million tons of washery refuse. The report forecast than an additional 3 million tons of refuse would accumulate in this region by 1974. These refuse piles act essentially like spoil banks, causing windborne dust contaminants and stream pollution from water leaching. More serious are the fumes from self-igniting piles. Visible smoke plumes from these mounds plus resultant SO_2, NO_x, CO and hydrocarbon-emissions present hazards not well documented. Based on a clean coal separation yield of 75% obtained by arithmetically averaging washed coals throughout the U.S., the amount of washery refuse produced in 1972 was 1.25 million tons for the entire West.[21] Techniques practiced to eliminate burning are compaction and regrading followed by planting.[82] Utilization of this refuse is more desirable because it would eliminate the "gob piles". In a few cases in the West, waste is being utilized, particularly cinder from burned refuse dumps, as fill in road construction and as a ceramic raw material.[82]

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[82] Geer, M. R. Disposal of Solid Wastes from Coal Mining in Washington, Oregon and Montana. Bureau of Mines Information Circular 8430. 1969. p. 38.

5.2 ENVIRONMENTAL EFFECTS OF WESTERN COAL TRACE ELEMENTS

Trace element accumulation in aquifers as a result of strip mining operations is largely unknown. The greatest concentrations of trace elements in coals occur near the coal seam partings. Coal seams form part of natural aquifers in certain western regions. Under normal static conditions the trace elements and carcinogenic material present in coal leach out slowly minimally affecting water quality. The spread of heavy metals or carcinogenic materials by rapid leaching and dilution may occur when coal seam disruption (i.e. mining) occurs.

The extent of trace elements in western coal is fairly well defined form some western areas (Section 3.5). The long-term effects on the environment as a result of combustion and airborne dust are largely undetermined. The composition of western coal and its overburden must be known for all minable areas to fully characterize and compare it with coals east of the Mississippi River. How trace elements are released and transported in the air as a result of combustion or gob pile burning is not fully understood. The uptake of transported trace elements in plant life, soils, and water systems must be studied. In addition, the potential hazards to human health from the utilization of coal obtained from coalfields located near or within radioactive ore deposits are undefined.

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[21] pp. 18-6.

[82] pp. 36-39, 1.

The increased utilization of trace element enriched by-products such as ash and coal refuse needs environmental definition. Ash has been used to promote successful revegetation of soil in the northern Great Plains area as described by Freeman, et al.[79] Use of fly ash in concrete roads has been highly acclaimed by many.[79] Sufficient data are not yet available to assess these types of environmental impacts.

5.3 SULFUR EMISSION CHARACTERISTICS

5.3.1 Total Sulfur

A question arises as to the sulfur emissions from small and intermediate size boilers converted to low sulfur western coal. Neglecting the derating of boilers which is perhaps necessary when western coals are burned, what is the net effect on sulfur emissions? The category of steam plants generating up to 250,000 lb steam per hour and requiring 240 MM Btu/hr of heat input are considered to be representative and inclusive of the terms "small" and "intermediate" size. The heat available to produce steam is defined as follows:

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[79] pp. 150-157, 138-149.

$$Q\left[\frac{\text{MM Btu}}{\text{hr}}\right] = 1.935 \times 10^{-4} \left[\frac{\text{Btu}}{\text{lb}}\right] \begin{bmatrix} 10^3 \text{ tons} \\ \text{burned} \\ \text{yearly} \end{bmatrix} \qquad (6)$$

Equation 6 relates the average yearly boiler capacity (Q) to the coal heating value (Btu/lb) and the tons of coal burned yearly. The above relation assumes a boiler efficiency of 85% and latent heat of evaporation $\approx$ 950 Btu/lb. The cutoff points for small and intermediate size boilers are:

10,000-100,000 lb steam/hr 9.5-95 MM Btu/hr	small
100,000-250,000 lb steam/hr 95-240 MM Btu/hr	intermediate

Total sulfur in coal is converted in the boiler to sulfur in fly ash (solid) and to sulfur in stack (gas). It may be assumed that total sulfur leaving the boiler is directly proportional to the boiler coal feed rate and the % sulfur in coal. A plot demonstrating the relationship between the total sulfur (expressed as elemental sulfur) leaving the boiler (millions of tons per year in stack and in ash), boiler capacity (Q), and % sulfur in coal for two types of coal (6000 and 12,000 Btu/lb net) is shown in Figure 63. Heat contents of 6000 and 12,000 Btu/lb were chosen to indicate the maximum change one may expect when converting from high quality subbituminous and bituminous coal to lignitic fuel. It is apparent from the plot that without a loss in boiler heating capacity, conversion of boilers using high sulfur eastern coals can only be effective in reducing total sulfur emissions from the stack and in the ash if the sulfur content of western coal is less than half of that for high sulfur fuel. For example, a boiler of

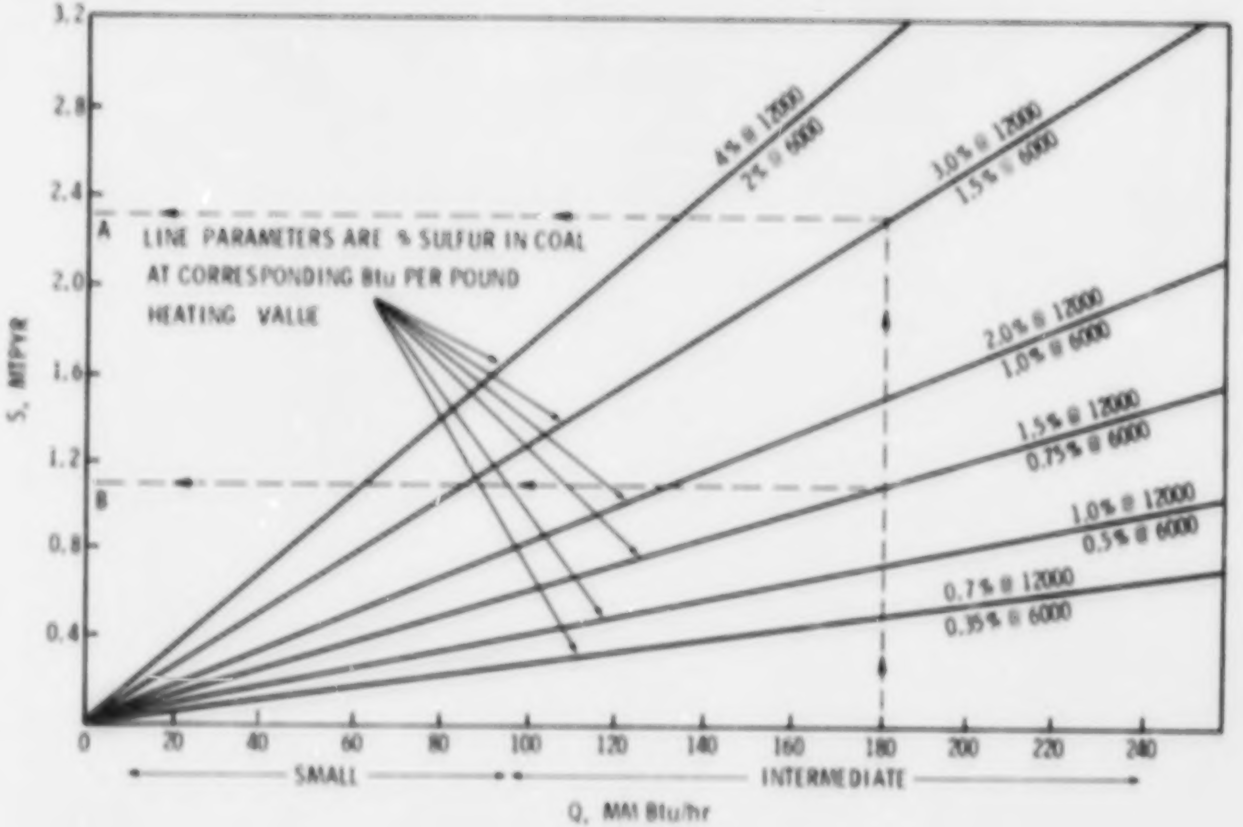

Figure 63. Relationship between total sulfur leaving the boiler, boiler capacity, sulfur in fuel, and heating value of fuel.

180 MM Btu/hr capacity utilizing 3% sulfur and 12,000 Btu coal would not experience a reduction in total sulfur emissions if a 1.5% sulfur 6000 Btu coal was substituted. Its sulfur tonnage would remain at 2.3 thousand tons per year (point A). Reducing the sulfur emissions to about half this amount requires a four fold reduction in sulfur content of the 6000 Btu per pound coal (point B).

The limitations of the plot in Figure 63 are that it only shows the changes if conversion is made from coal with a heating value of 12,000 Btu/lb to lignite of 6000 Btu/lb. Should the change in heating values of the two fuels be less dramatic, higher sulfur content of the substituted fuel may be allowed.

Also, the vertical axis represents the total elemental sulfur leaving the boiler in both ash and flue gas streams. The sulfur emitted to the atmosphere, however, is of major concern. The distribution of total sulfur between the gas and ash stream varies greatly with properties and composition of coal and will influence emissions of sulfur to the atmosphere. In the following two sections an attempt is made to quantify the distribution of total sulfur in fuel between ash and flue gas.

5.3.2 Sulfur Oxides

A more meaningful representation of sulfur balance around a boiler is in the form of SO_x emissions through the stack as a function of boiler heat input. Available data were compiled and are shown in Figure 64. The raw data are given in Table 52.

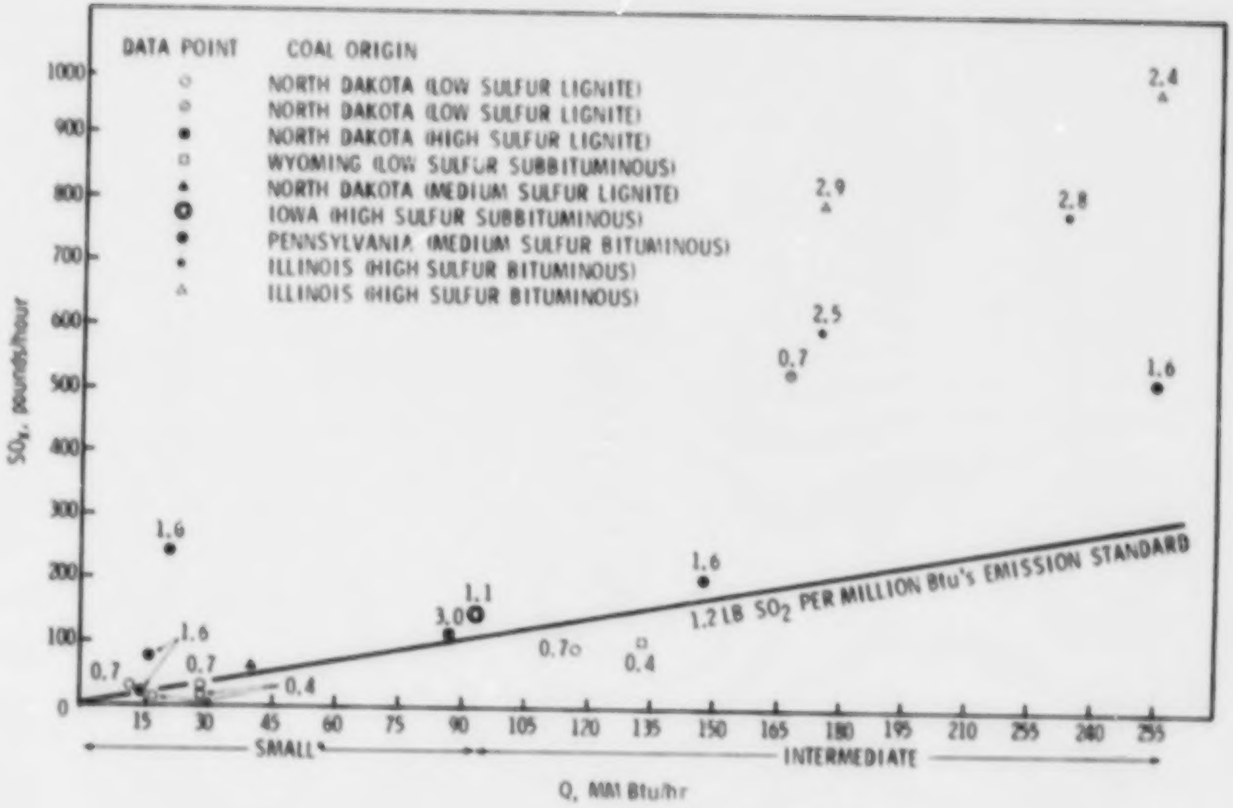

Figure 64. SO_x rate as a function of boiler size
(% sulfur in coal given per data point; symbols identified in Table 55)

The above data were compiled from three sources. The M. W. Kellogg report provided data on the amount of coal burned in 1972, along with sulfur content, calorific value and boiler identification (except for the Illinois boilers). Average yearly heat input per boiler on an hourly basis was calculated from annual Btu consumption found in the Kellogg Report. It was assumed that boilers operated 366 days and 24 hours/day (8784 hours/year). Only values of average yearly heat input which fell in the range of small and intermediate size boilers were considered. The SO_x mass rate of emissions per boiler and stoker type were found in the NEDS Data Condensed Point Source Files for Utility Boilers, May 15, 1974. The criterion for correspondence between the NEDS file and the Kellogg report was that boiler nomenclature numbers were identical between the two file systems. Because the nomenclature numbers are normally designated by the utility company, the boilers identified by the same numbers should be identical. Only those SO_x values which were calculated by actual stack sampling or material balances were included in Figure 64.

The Illinois boiler data were gathered from an EPA report that gave SO_2 and SO_3 emissions in volume ppm for two boilers burning high sulfur (3%) coal and fitting the small and intermediate classification.[85] SO_x mass emission rates for the Illinois boilers were calculated from the SO_2-SO_3 concentration figures and stack volumetric flow rates given. Equation 7 was used to calculate the SO_x mass emission rate for the Illinois boilers.

$$SO_x[\text{lb/hr}] = 1.021 \times 10^{-5}\ [\text{vppm } SO_x][\text{stack gas rate scfm}] \quad (7)$$

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[85] pp. 1-26.

Table 52. EMISSIONS DATA[83,84,85]

[illegible]

Equation (7) assumes that the stack gas behaves as an ideal gas (particulate free) and that the molecular weight of SO_x is 64, that of SO_2.

The general trend of Figure 64 seems to indicate that SO_x emission rate (i.e. SO_2, SO_3) increases with boiler size and coal sulfur content even though there are significant deviations from this trend. The Federal emission standard of 1.2 lb SO_2 per million Btu's fired is shown for reference (1971 standard in effect). Some liberty was taken in drawing the SO_2 line on an SO_x plot. However, the majority of SO_x emissions originate in the boiler as SO_2 (with some coal to coal variations) and it is felt that only slight error is introduced by assuming all SO_x as SO_2. (Note: the Illinois boiler data reported both SO_2 and SO_3 and showed only negligible formation of SO_3).

All data points lying below the standard line in Figure 64 are seen to be representative of low sulfur western coal. Boiler data points above the line do not meet standards. The majority of the points which do not meet the standards are seen to be indicative of intermediate and high sulfur coals from the East and Mid-West. High and medium sulfur lignite (3% and 1.1% respectively) are seen to also be above the standard as would be expected with the low heating value associated with this coal. A notable exception is a "low-sulfur" lignite burned at Mandon, North Dakota which appears to be substantially above standard.

No definite conclusions can be drawn from Figure 64 due to unknown experimental accuracy of the data and lack of information on intermediate size western coal burning boilers. There is also some doubt as to the correspondence between the NEDS data and the M. W. Kellog data used since they have been generated for different base years. Our method of calculating average yearly heat input probably resulted in inclusion of some boilers larger than intermediate size, but all boilers of small and intermediate size for which data were available are included. Figure 64 indicates, however, the extent of data availability as well as the complexity of the decision that has to determine whether western coal will or will not meet the sulfur emission standard. Considerable scatter in the data suggests that more variables than those shown in Figure 64 affect SO_x emissions. Examples of correlating variables which were not available from the given data sources include percent ash in coal, percent sulfur in ash, and fractional conversion of SO_2 to SO_3 in the stack. It appears that each western coal will have to be evaluated individually in relation to meeting the sulfur emission standard and the following section will attempt to provide a method of this evaluation utilizing data presently available.

5.3.3 Coal Selection Criteria

The somewhat sparse and inconclusive data shown in Figure 64 only partially explain why there is an increasing interest in western coals as purporters of low sulfur emissions. It was seen that western coal burning boilers in the small and intermediate size class can meet Federal standards of 1.2 lb SO_2 per million Btu's of heat input even though some noteworthy exceptions to meeting the standards can exist.

When burning low sulfur coals the retention of sulfur in the ash becomes an important and influencing parameter for determination of sulfur emissions through the stack. It is apparent from a sulfur material balance that the more sulfur that is retained or bound in the ash, the less will be emitted to the atmosphere. The following example will illustrate the importance of bound sulfur in coal ash.

Let us consider two coals with the following properties:

Coal	Btu/lb (as fired)	% Ash In coal	% S In Coal	Sulfur in Ash (Reported as %SO_3)
A	9,000	9	0.7	4.5
B	13,500	9	3.0	9.0

The total sulfur material balance can be expressed as follows:

$$S_{coal} = S_{stack} + S_{ash} \tag{8}$$

Sulfur in stack, S_{stack}, is subject to Federal standard of 1.2 lb SO_2 per 10^6 Btu's boiler heat input (0.6 lb S per 10^6 Btu's). In order to express the S_{stack} in the unit of the standard, S_{coal} and S_{ash} will be modified as follows:

$$S_{coal} = 10^6 \frac{\overline{X}_s}{Btu} \tag{9}$$

$$S_{ash} = \frac{32 x 10^2}{80} x \left(\frac{\overline{X}_{SO_3} x \overline{X}_{ash}}{Btu} \right) \tag{10}$$

where $\bar{X}_s$ = sulfur content of coal in %-wt

Btu = the heating value of coal in Btu/lb

$\bar{X}_{SO_3}$ = sulfur content of ash (as SO_3) in %-wt

$\bar{X}_{ash}$ = ash content of coal in %-wt

Combining Equations (9) and (10) with Equation (8) yields:

$$S_{stack}(\text{lb S}/10^6\text{ Btu}) = 10^4\,\frac{\bar{X}_s}{\text{Btu}} - \frac{32\text{x}10^2}{80}\,\text{x}\left(\frac{\bar{X}_{SO_3}\ \text{x}\ \bar{X}_{ash}}{\text{Btu}}\right) \quad (11)$$

To express S_{stack} in lb SO_2/ 10^6 Btu's the following equation may be used:

$$S^*_{stack}\ (\text{lb SO}_2/\ 10^6\text{ Btu}) = 2.0\left[10^4\,\frac{\bar{X}_s}{\text{Btu}} - \frac{32\text{x}10^2}{80}\,\text{x}\left(\frac{\bar{X}_{SO_3}\ \text{x}\ \bar{X}_{ash}}{\text{Btu}}\right)\right] \quad (12)$$

Applying Equation (12) to the two coals assumed above produced results summarized below:

Coal	S^*_{stack}, No Sulfur Retained in Ash ($\bar{X}_{SO_3}$ = 0) (lb $SO_2/10^6$Btu)	S^*_{stack}, Sulfur Retained in Ash (lb $SO_2/10^6$ Btu)
A	1.56	1.20
B	4.44	3.96

If none of the sulfur is retained in ash it is evident from Equation (12) that neither the low sulfur coal or the high sulfur coal meets the standard of 1.2 lb of SO_2 per million Btu's. However, correction for sulfur retention in ash shows that coal A can meet the EPA standard readily if the sulfur in ash is at least 4.5% (expressed as $\%SO_3$ in ash). The coal B with double the sulfur retention in ash (9%) cannot meet the standard.

Figure 65 summarizes the sulfur retention concept for typical eastern and western coals with respect to the EPA standard. In constructing this figure coals having 0.7% sulfur and heat values ranging from 6000 to 11,000 Btu per lb were chosen to represent western coals. Coals in the heat value range from 10,500 to 14,000 Btu per lb and 3% sulfur in coal were chosen to represent eastern coals. All coals were assumed to have 9% ash in coal. If no sulfur is contained in the resulting ash, it is seen that both the 0.7% and the 3% sulfur coals do not meet the emission standard (lines 1 and 3) for any heating value. However, if 5% sulfur remains in ash the 0.7% sulfur western coals meet standards readily for the entire heating value range (line 4). Even with 5% sulfur in ash the protrayed eastern and midwestern coals cannot meet the standard (line 2).

The amount of sulfur trapped in the ash along with low inherent sulfur in coal are both important for low sulfur emissions. Using the data of Table 28 an indication of sulfur ash contents in western, interior, and eastern coals may be obtained. These data are presented in Table 53.

As shown in Table 53, western coals appear to have higher affinity for sulfur in coal ash (maximum %S average in ash = 8.2 versus 1.2 and 0.8 for non-western coals). Neither interior nor eastern province coals meet the 5% sulfur in ash best case assumption used in Figure 65.

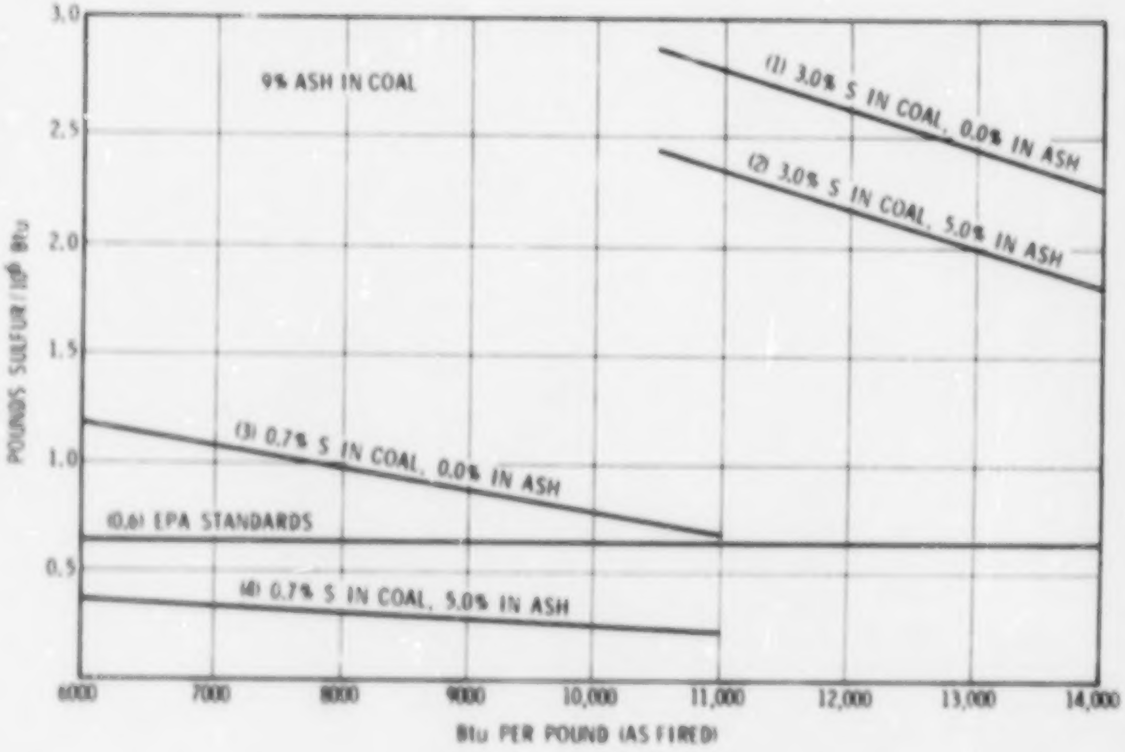

Figure 65. Comparison of 9% western and eastern coals at 0% and 5% sulfur in ash

Table 53. SULFUR RANGE IN COAL ASH
(reported as SO_3 from Table 28)

Region	Average range % SO_3 in Ash	Average range[a] % S in ash	Minimum[a]		Maximum[a]	
			% SO_3	% S	% SO_3	%S
Western states	3.6 - 20.6	1.4 - 8.2	0.2	0.08	27.4	10.96
Interior province	1.1 - 3.1	0.4 - 1.2	0.2	0.08	10.3	4.12
Eastern province	1.6 - 2.1	0.6 - 0.8	0.2	0.08	9.6	3.84

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[a] %S = 0.4 x % SO_3

The selection of western coal for SO_x reduction cannot simply be based on % sulfur in coal and coal heating value. The minimum sulfur content in coal ash in western coal can be as low as 0.08% as seen in Table 53. This indicates that some of the western coals, even though having low coal sulfur content, may not be able to meet the EPA regulation. In light of this the high SO_x value shown by the Mandon, South Dakota plant which burns 0.7% sulfur coal (6970 Btu's) appears reasonable if the sulfur content in ash of this coal is low (see Figure 64). However, this could not be verified since the ash sulfur content was not available.

The superior retention of sulfur in some western coal ash perhaps explains why some power plant operators mix selected western coals with high-sulfur coal to meet the SO_2 emission standard. The sulfur retention by ash is a function of ash alkalinity, ash fusibility and perhaps other ash and coal combustion properties that influence the boiler design. As such, the sulfur ash content should be considered an important variable in converting existing boilers to western coal fuels and in determining the sulfur emissions.

In selecting western coals which can meet the SO_2 standard it is thus important to know the minimum value of % sulfur in ash. A relationship based on **Equation** 12 is proposed as a tentative guideline to facilitate coal selection. In order for a coal to meet the present standard, S^*_{stack} must be $\leq$ 1.2 lb $SO_2/10^6$ Btu. Substituting this value in Equation (12) and after some rearrangement of the variables we obtain:

$$\bar{X}_{SO_3} = \frac{250}{\bar{X}_{ash}} \times (\bar{X}_S - 0.6\ \text{Btu} \times 10^{-4}) \qquad (13)$$

The fractional conversion of SO_2 to SO_3 (Y_{SO_3}) is usually quite small for all coal fired plants. For completeness, however, this factor is included since it may aid in the experimental verification of Equations (13) and (14). Typically, the mole fraction of SO_3 in SO_x is 0.02.[86]

After introducing the mole fraction of SO_2 oxidized to SO_3 (Y_{SO_3}) into Equation (13) we obtain Equation 14:

$$\bar{X}_{SO_3} = \frac{250}{\bar{X}_{ash}} \times \left(\bar{X}_s - \frac{0.6 \text{ Btu} \times 10^{-4}}{1-Y_{SO_3}} \right) \qquad (14)$$

Equation (14) is plotted in Figure 66 for various sulfur contents in coal at 9% ash in coal and 2% SO_3 in SO_x. Similar plots could be prepared for different coal ash contents and SO_2-to-SO_3 conversions.

The band between 9,600 and 11,700 Btu's per lb heating value represents the overlap between western and non-western coal average values derived from Table 27. The ceiling limits for sulfur content in ash of western and non-western coals were obtained from Table 53. These limits indicate that a maximum of 10% sulfur in coal (as SO_3) can be retained by non-western coals and 27% sulfur in coal (SO_3) can be retained by western coals. The example below illustrates the use of Figure 66.

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[86] Welty, A. B. Fundamentals of Sulfur Oxide Removal from Stack Gases. Esso Research and Engineering Company. (For presentation at the 63rd Annual Meeting of the Air Pollution Control Association, St. Louis, Missouri, June 14-18, 1970). p. 28.

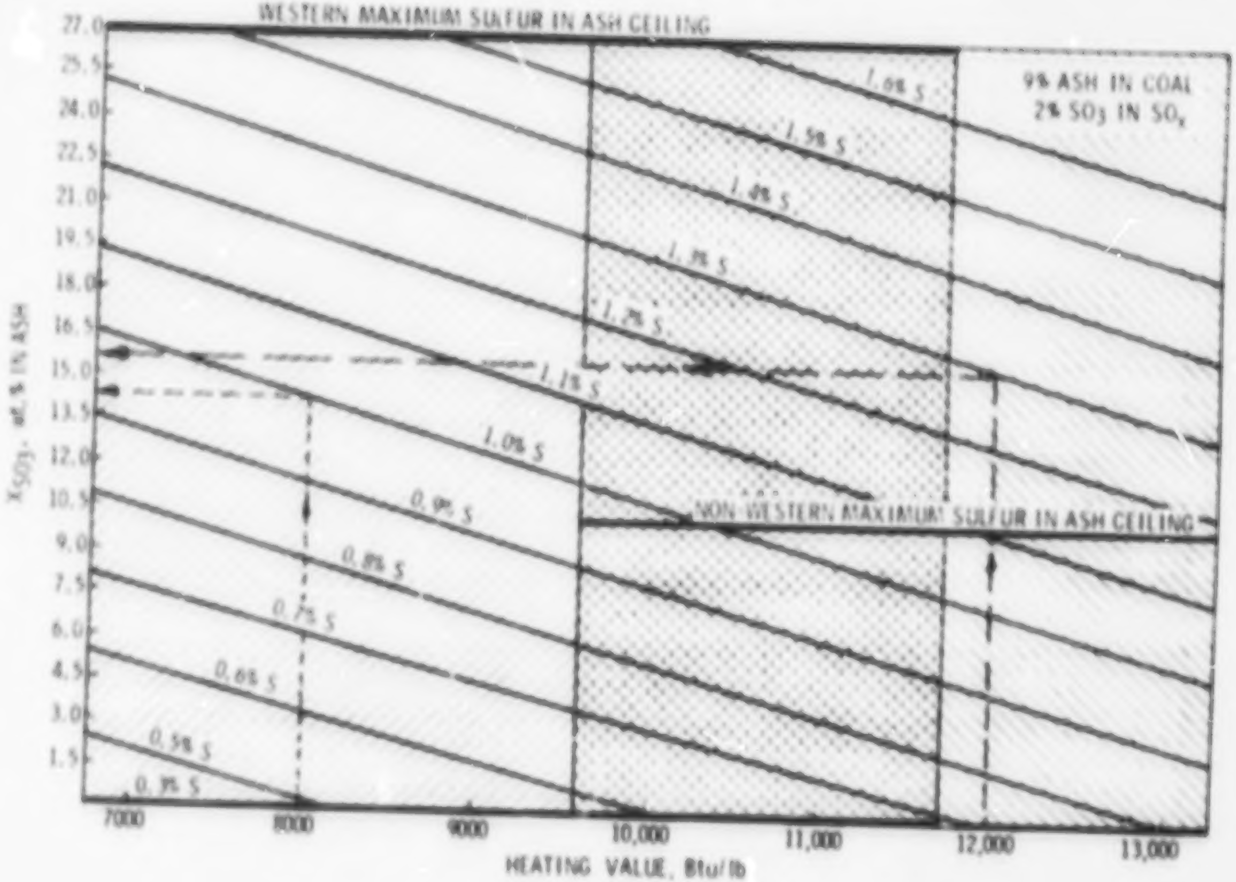

Figure 66. Minimum sulfur retention required in ash to meet SO_x standard of 1.2 lb $SO_x/10^6$Btu

The minimum sulfur retention in ash ($\overline{X}_{SO_3}$) for western coal with 8000 Btu/lb (as fired) and 1.0% sulfur in order to be in compliance with the present standard is 14.3% (point A).

For 12,000 Btu/lb (as fired) non-western coal with 1.3% sulfur the value is 15.6% (point B). However, the standard will most probably not be met as the maximum ceiling for non-western coals is 10% as indicated by the heavy horizontal line.

Figure 66 indicates that non-western coals with 9% ash probably will not meet the standard if they contain more than 1.0% sulfur. Western coals will probably not meet standard if they contain more than 1.3% sulfur. Other families of curves should be prepared and consulted for coals with ash values different from the 9% value used in Figure 66.

A laboratory check on the "as-fired" coal for % sulfur retention in ash ($\overline{X}_{SO_3}$) is then made to determine if the actual value is above or below the minimum value obtained from Equation 14. This ultimately indicates the coal's potential to meet the sulfur emission standard. The sulfur retention in ash can routinely be determined, for example, by a method outlined by the American Society of Testing Materials. This method, ASTM D1757-62, gravimetrically determines sulfur (as SO_3) in coal ash via barium sulfate precipitation.[87]

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[87] Anon. Standard Method of Test for Sulfur in Coal Ash - ASTM D1757-62 from Annual Book of ASTM Standards - Part 19: Gaseous Fuels; Coal and Coke, American Society for Testing and Materials, Philadelphia, Pennsylvania, 1972, pp. 260-261.

It must be realized that Equation (14) (and Figure 66) should be interpreted solely as a guideline as it has not been experimentally verified. It is proposed that the relationship be verified by compiling information on sulfur content of coal ($\bar{X}_s$), sulfur content of ash ($\bar{X}_{SO_3}$) coal heating value (Btu), ash content of coal ($\bar{X}_{ash}$), and sulfur emissions through the stack (S^*_{stack}).

The significance of these variables and their influence on the accuracy of SO_x emission determination must be examined. The data for Equation (14) may be largely available through boiler operator records as well as EPA files. Upon verification the relationship may aid in selection of proper substitute fuel and the necessary modifications to the boiler in order for it to comply with the sulfur emission standard.

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APPENDIX A

WESTERN COAL RESERVES BY FIELD

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Table A-1 represents a compilation of reproduced data available from open file literature. The data is organized by coalfield or deposit, both terms being synonymous. The overburden thickness categories represent the categories of the original data. No attempt has been made to subtract coal production for the years following the estimate. In the majority of cases the individual tonnage figures have not been distorted by additions or averages from several sources. The specific measured, indicated, measured and indicated, and inferred categories are as defined in Section 1.1.

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Table A-1. COAL RESERVES BY OVERBURDEN THICKNESS[illegible]
(millions of short tons & feet of overburden)

State, Region, Field(s) and Seam(s)	Measured	Indicated	Measured and Indicated	Inferred
	Arizona - Black Mesa Region[illegible]			
Black Mesa				
([illegible], [illegible], [illegible])				
0-[illegible]	--	--	[illegible]	--
0-[illegible]	--	--	--	[illegible]
0-[illegible] Total	--	--	[illegible]	--
0-[illegible] Total	--	--	--	[illegible]
	Colorado - San Juan Region[illegible]			
[illegible]				
([illegible])				
0-[illegible]	[illegible]	--	--	[illegible]
[illegible]	--	--	--	[illegible]
0-[illegible]	--	--	--	[illegible]
[illegible]				
([illegible])				
0-[illegible]	--	--	--	[illegible]
Durango*				
([illegible], [illegible])				
0-[illegible]	--	--	[illegible]	[illegible]
[illegible]	--	--	--	[illegible]
	Colorado - Uinta Region[illegible]			
Book Cliffs				
([illegible])				
0-[illegible]	--	--	[illegible]	[illegible]
[illegible]	--	--	--	[illegible]
Grand Mesa				
([illegible])				
0-[illegible]	--	--	[illegible]	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]				
([illegible])				
0-[illegible]	--	--	--	[illegible]
0-[illegible]	--	--	--	[illegible]
Somerset				
([illegible], [illegible])				
0-[illegible]	--	--	[illegible]	[illegible]
[illegible]	--	--	--	[illegible]
Crested Butte				
([illegible])				
0-[illegible]	--	--	[illegible]	[illegible]
[illegible]	--	--	--	[illegible]

*Durango Field = "[illegible]" • [illegible] • [illegible]

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Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,44-180]
(millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
		Colorado Uinta Region (cont.)		
Carbondale (Garfield)				
0-[illegible]	--	--	--	2,870
0-1000	--	--	1,110	--
[illegible]-6000	--	--	--	2,700
Grand Hogback (Garfield)				
0-3000	--	--	581	766
3000-6000	--	--	--	1,953
Danforth Hills (Rio Blanco)				
0-3000	--	--	7,911	189
3000-6000	--	--	--	7,199
Lower White River (Rio Blanco)				
0-3000	--	--	--	11,779.41
3000-6000	--	--	--	7,598
		Colorado - Green River Region[1,71]		
Yampa (Routt)				
0-3000	--	--	--	79,097
		Colorado - Raton Basin Region[1]		
Walsenburg (Huerfano)				
0-700	--	--	--	1,480
Trinidad (Las Animas)				
0-3000	--	--	--	11,880
3000-6000	--	--	--	297
		Colorado - Canon City Region[1,71]		
Canon City (Fremont)				
0-700	--	--	--	217
0-3000	--	--	--	296
		Colorado - South Park Region[1,71]		
South Park (Park)				
0-3000	--	--	--	57.5
North Park (Jackson)				
3000-6000	--	--	--	75,000
Middle Park (Grand)	--	--	No minable seams	

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[illegible]

(millions of short tons & feet of overburden)

State, Region, Deposit and (Counties)	Measured	Indicated	Measured and Indicated	Inferred
	Colorado - Denver Basin[illegible]			
Colorado Springs (El Paso, Elbert, Douglas) 0-1000	--	--	--	[illegible]
Boulder-Weld (Weld, Jefferson, Boulder, Denver, Arapahoe) 0-1000	--	--	--	[illegible]
0-200 Total	11.1	--	--	[illegible]
[illegible] Total	--	--	--	[illegible]
[illegible] Total	--	--	--	[illegible]
[illegible] Total	--	--	[illegible]	[illegible]
[illegible] Total	--	--	--	[illegible]
[illegible] Total	--	--	--	[illegible]
[illegible] Total	--	--	--	[illegible]
	[illegible]			
[illegible] ([illegible]) [illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible] ([illegible], [illegible], Powder River) [illegible]	--	[illegible]	--	--
[illegible]	--	--	--	[illegible]
Moorhead (Powder River) [illegible]	--	[illegible]	--	--
[illegible]	--	--	-	[illegible]
[illegible] ([illegible]) [illegible]	--	[illegible]	--	--
[illegible]	--	--	--	[illegible]
Squirrel Creek ([illegible]) [illegible]	--	[illegible]	--	--
[illegible]	--	--	--	[illegible]
[illegible] ([illegible]) [illegible]	--	--	--	[illegible]
[illegible] ([illegible]) [illegible]	--	[illegible]	--	--
[illegible]	--	--	--	[illegible]

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,3,44-108]
(millions of short tons; # feet of overburden)

State, Region Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Montana - Fort Union Region (cont.)				
Canyon Creek (Rosebud)				
0-200	--	--	--	[illegible]
0-250	--	[illegible]	--	--
Poker Jim O'Dell (Rosebud)				
0-200	--	--	--	779
0-250	--	[illegible]	--	--
Otter Creek (Powder River)				
0-200	--	--	--	1,941
0-250	-	[illegible]	--	--
Ashland (Powder)				
0-200	--	--	-	7,536
0-250	--	[illegible]	--	--
[illegible] Creek (Powder River)				
0-200	--	--	--	55
Beaver Creek (Powder River)				
0-150	--	127.13*	--	--
0-200	--	--	--	266
Liscom Creek (Custer)				
0-225	--	--	--	75
Miller-Greenleaf Creek (Rosebud)				
0-150	--	453.71	--	--
0-200	--	--	--	512
Sweeney - Snider Creek (Rosebud)				
0-150	--	496.16	--	--
0-200	--	--	--	327
Colstrip (Rosebud)				
0-150	--	1,419.36	--	--
0-200	--	--	--	1,440
Sarpy Creek (Treasure, Big Horn)				
0-200	--	--	--	1,500
Fire Creek** (Powder River)				
0-200	--	71.7	--	45***

*Beaver Creek + Liscom
**Pinto Creek + Fire Creek deposits
***Fire Creek only

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,3,88-100] (millions of short tons & feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Montana Fort Union Region (cont.)				
Upper Cache Creek (Powder River) 0-200	--	78.55	--	80
Lower Cache Creek (Powder River) 0-200	--	39.51	--	38
Sonnette (Powder River) 170-255 0-200	-- --	-- 908.41	-- --	153.06 206
Pumpkin Creek (Powder River) 0-200 0-250	-- --	2,476.58 --	-- --	-- 1,898
Broadus (Powder River) 0-215 0-200	-- --	758.82 --	-- --	-- 737
Sand Creek (Custer, Powder River) 0-150 0-200	-- --	267.16 --	-- --	-- 333
Foster Creek (Custer) 0-120	--	--	--	1,130
Pine Hills (Custer) 0-150 0-200	-- --	193.87 --	-- --	86.04 280
Lame Jones (Fallon) 0-200	--	--	--	150
East Moorhead (Powder River) 0-150 0-200	-- --	525.21 --	-- --	-- 531
Knowlton (Custer) 0-150 0-200	-- --	667.92 --	-- --	-- 731
Lancaster (Wibaux) 0-200	--	--	--	35

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[illegible]
(millions of short tons [illegible] feet of overburden)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				
[illegible]	--	[illegible]	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	
[illegible]	--	--	--	
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	--	[illegible]

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]
(millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Montana - Fort Union Region (cont.)				
Lane (Richland) 0-250	--	--	--	161
Girard (Richland, Dawson) 0-200	--	--	--	841
Fort Kipp (Roosevelt) 0-200	--	--	--	811
[illegible] (Roosevelt) 0-250	--	--	--	[illegible]
Medicine Lake (Sheridan) 0-200	--	--	--	16
Reserve (Sheridan) 0-250	--	--	--	246
Coal Ridge (Sheridan) 0-200	--	--	--	250
Cheyenne Meadows (Rosebud)	--	--	--	1,200
Little Wolf (Big Horn) 0-250	--	--	--	334
Jeans Fork (Big Horn) 0-200	--	--	--	94
Wolf Mountain (Big Horn) 0-250	--	--	--	1,920
Deer Creek (Big Horn) 0-150	--	495.45	--	--
Kirby (Big Horn) 0-250	--	1,601.04	--	--
[illegible] (Powder River) 0-150	--	1,971.42	--	--

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,3,98-100]
(millions of short tons × feet of overburden)

State, Region, Deposit and (Counties)	Measured	Indicated	Measured and Indicated	Inferred
Montana - Fort Union Region (cont.)				
Little Pumpkin Creek (Powder River) 0-150	--	[illegible]	--	--
[illegible] (Powder River) 0-150	--	[illegible]	--	--
[illegible] Butte* (Powder River) 0-150	--	[illegible]	--	--
[illegible] Butte (Powder River) 0-150	--	[illegible]	--	--
Montana - Bull Mountain Region				
[illegible] (Musselshell, Yellowstone)	[illegible]	[illegible]		
[illegible] (Musselshell) 0-[illegible]	--	--	--	[illegible]
[illegible] (Musselshell) 0-[illegible]	--	--	--	[illegible]
Montana - Red Lodge Region				
Red Lodge (Carbon, Stillwater)	Very small amount present (no value)			
Bridger (Carbon)	Very small amount present (no value)			
Silvertip (Carbon)	Very small amount present (no value)			
Stillwater (Stillwater)	Very small amount present (no value)			
Montana - Great Falls/Lewistown Region				
Great Falls (Cascade) 0-150	--	--	[illegible]	[illegible]
Lewistown ([illegible])		[illegible]	[illegible]	

*[illegible] Butte = [illegible] Butte + [illegible]

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100] (millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Montana - Electric Field Region[1]				
Electric (Park)	?	?	?	?
Montana - Livingston/Trail Creek Region[43]				
Livingston - Trail Creek (Gallatin, Park) 0-1000	--	--	[illegible]	[illegible]
Montana - Lombard Region[1]				
Lombard (Gallatin, Broadwater)	?	?	?	?
Montana - Flathead Region[1]				
Flathead (Flathead)	Very small amount present and minable			
Montana - Western Tertiary Fields[1]				
Combined Fields (Granite)	?	?	?	?
0-150 Totals	--	431.5	--	--
0-250 Totals	--	15,994.1	--	1,276.1
0-300 Totals	--	7,962.7	915	26,747
0-350 Totals	--	6,067.1	--	4,156.9
?-1000 Totals	--	--	--	9,099
0-1000 Totals	--	--	245.7	55.7
New Mexico - San Juan Region[1,91,92]				
Fruitland (San Juan)				
0-150	91.0	--	--	--
150-250	65.0	--	--	--
Navajo (San Juan)				
0-150	--	--	1,309.7	--
150-250	--	--	1,950.9	--
Bisti (San Juan)				
0-150	--	--	--	961.0
150-250	--	--	--	912.0
Star Lake (San Juan, McKinley)				
0-150	--	--	--	605.2
150-250	--	--	--	279.0
Barker Creek (San Juan)	No strippable, but some underground reserves			
[illegible] (San Juan)	No strippable, but some underground reserves			

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-108]
(millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
New Mexico - San Juan Region[illegible]				
Toadlena (San Juan)	No strippable, but some underground reserves			
Newcomb (San Juan)				
0-150	--	--	--	[illegible]
150-250	--	--	--	[illegible]
[illegible] (San Juan)				
0-150	--	--	--	[illegible]
[illegible] Mesa (McKinley)				
0-150	--	--	--	[illegible]
Standing Rock (McKinley)				
0-150	--	--	--	[illegible]
150-250	--	--	--	[illegible]
Zuni (McK.,[illegible])				
0-150	--	--	--	[illegible]
South Mount Taylor (Valencia)				
0-150	[illegible]	--	--	[illegible]
La Ventana (Sandoval)				
0-150	--	--	--	[illegible]
Rio Puerco (Sandoval)	Mined for local use only			
[illegible] (Sandoval)				
0-[illegible]	[illegible]	[illegible]	--	[illegible]
[illegible]	--	[illegible]	--	[illegible]
[illegible]	--	[illegible]	--	[illegible]
[illegible]				
0-[illegible]	[illegible]	[illegible]	--	[illegible]
[illegible]	--	[illegible]	--	[illegible]
[illegible]	--	[illegible]	--	[illegible]
[illegible]				
0-[illegible]	[illegible]	[illegible]	--	[illegible]
[illegible]	--	--	--	[illegible]
[illegible]	--	--	[illegible]	[illegible]

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]
(millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
New Mexico - San Juan Region (cont.)				
McKinley County (Includes Gallup, and Crownpoint fields)				
0-1000	233.8	239.4	--	10,036.4
1000-2000	--	--	--	1,848.9
2000-3000	--	--	--	836.2
San Juan County				
0-1000	594.5	1,062.5	--	7,771.8
1000-2000	--	166.5	--	11,327.6
2000-3000	--	13.6	--	11,594.4
New Mexico - Raton Region[92]				
Raton (Colfax)				
0-1000	567.9	1,189.6	--	703.2
1000-2000	--	107.0	--	1,739.2
2000-3000	--	--	--	402.1
New Mexico - Cerrilos Region[92]				
Cerrilos (Santa Fe)				
0-1000	9.0	14.3	--	0.7
1000-2000	0.4	3.2	--	25.6
New Mexico - Tijeras[92]				
Tijeras (Bernalillo)				
0-1000	0.4	1.2	--	--
New Mexico - Carthage[92]				
Carthage and Jornado del Muerto (Socorra)				
0-1000	19.7	14.3	4.7	--
New Mexico - Sierra Blanca[92]				
Sierra Blanca (Lincoln, and Otero)				
0-1000	3.3	8.0	--	758.3
1000-2000	--	--	--	558.7
2000-3000	--	--	--	315.7

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]

(millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
New Mexico - Datil Mountain[97]				
Datil Mountain (Valencia, Catron, and Socorro)				
0-1000	--	--	--	737.1
1000-2000	--	--	--	583.9
0-150 Totals	93.0	--	1,024.7	1,538.4
150-250 Totals	65.0	--	1,352.8	1,263.3
0-1000 Totals	1,421.5	2,839.2	4.7	21,775.8
1000-2000 Totals	0.4	337.2	--	18,304.4
2000-3000 Totals	--	19.3	--	17,201.6
North Dakota - Northwestern[98]				
Noonan-Kincaid (Burke) 0-200	--	--	15	--
Niobe (Ward, and Burke) 0-200	--	--	146	--
Avoca (Williams) 0-200	--	--	380	--
M. and M. (Williams) 0-200	--	--	100	--
Velva (Ward) 0-200	--	--	5	--
North Dakota - Southwestern[99]				
Washburn (Mclean) 0-200	--	--	30	--
Wilton (Burleigh) 0-200	--	--	15	--
Renner's Cove (Mercer) 0-200	--	--	78	--
Hazen (Mercer)	--	--	71	--
Beulah-Zap (Mercer) 0-200	--	--	590	--
Stanton (Mercer, and Oliver) 0-200	--	--	21	--

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]
(millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
North Dakota - Southwestern (cont.)				
Center (Oliver) 0-200	--	--	253	--
Dunn Center (Dunn) 0-200	--	--	1,500	--
Dickinson (Billings, Dunn, and Stark) 0-200	--	--	798	--
Beach (Golden Valley) 0-200	--	--	450	--
Bowman - Gascoyne (Slope, and Bowman) 0-200	--	--	1,372	--
New Leipzig (Grant, and Hettinger) 0-200	--	--	105	--
0-200 Totals	--	--	5,719	--
Oregon - Coos Bay[9]				
Coos Bay (Coos) 0-1500	23.76	27.00	--	15.11
Oregon - Eden Ridge[9]				
Eden Ridge (Coos, and Curry)	Relatively inaccessible			
Rogue River	Little exploration, many impurities in the coal			
Eckley	No production - many flats and folds in coal beds			
John Day	Coal impure - low Btu value, beds highly faulted and folded			
0-1500 Totals	23.76	27.00	--	15.11
South Dakota - Upper Northwest[95]				
Upper Northwest 0-1000	--	--	--	1,000 to 1,500
0-1000 Totals	--	--	--	1,000

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]

(millions of short tons @ feet of overburden)

State, Region Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
	Utah - Southwestern[98]			
Alton (Kane & Garfield)				
0-200	--	--	--	200
0-1000	--	--	--	1,000
1000-3000	--	--	--	900
Kaiparowits Plateau (Kane & Garfield) 0-3000	--	--	--	15,200
Kolob & Harmony (Iron, Washington and Kane) 0-2000	--	--	--	2,000
	Utah - Central[96]			
Mt. Pleasant (Sanpete) 0-1000	--	249.1	--	--
Salina Canyon (Sevier) 2000-3000	--	--	--	85
Sterling (Sanpete) 2000-3000	--	--	--	7
Wales (Sanpete) 2000-3000	--	--	--	27
Wasatch Plateau (Carbon, Emery, Sanpete, and Sevier) 0-3000	--	--	--	3,500
Book Cliff (Carbon and Emery) 0-3000	--	--	--	1,000
Emery (Emery and Sevier) 0-3000	--	--	--	750
	Utah - Eastern & Northern[1,95,97]			
Vernal (Uintah) 0-3000	--	--	--	175

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]
(millions of short tons @ feet of overburden)

State, Region Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Utah - Eastern & Northern (cont.)				
Henry Mts. (Wayne and Garfield)				
0-200	--	--	--	[illegible]
0-1000	--	--	--	[illegible]
[illegible] (Uintah [illegible])				
0-1000	--	--	--	[illegible]
[illegible] - [illegible] ([illegible])	--	--	--	--
	No reserves over 4 feet thick			
Tabby Mts. (Wasatch and Duchesne)				
0-1000	--	--	--	231
Coalville (Summit)				
0-1000	--	--	--	186
Henrys Fork (Uintah)	Low occurrence of coal			
Goose Creek (Box Elder)	Low occurrence of coal			
Lost Creek (Morgan)				
0-1000	--	--	--	1.1
	Low occurrence of coal			
0-200 Totals	--	--	--	[illegible]
0-1000 Totals	--	249.1	--	[illegible]
1000-3000 Totals	--	--	--	[illegible]
0-3000 Totals	--	--	--	[illegible]
3000-6000 Totals	--	--	--	[illegible]
0-6000 Totals	--	--	--	[illegible]
Washington - Kelso Castle Rock Area[1]				
Kelso-Castle Rock (Cowlitz, and Lewis)				
0-1000	--	--	--	[illegible]
Washington - Roslyn[1,100]				
Roslyn (Kittitas)				
0-1000	--	--	--	[illegible]

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]
(millions of short tons @ feet of overburden)

State, Region, Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Washington - Taneum Manastash[1,100]				
Taneum - Manastash (Kittitas) 0-3000	--	--	--	40
Washington - Eastern Lewis County[1,100]				
Eastern Lewis County (Lewis) 0-3000	--	--	--	4
Washington - Issaquah Grand Ridge[1,100]				
Taylor (King) 0-3000	--	--	--	18
New Castle-Grand Ridge (King) 0-3000	--	--	--	61[illegible]
Cedar Mountain (King) 0-3000	--	--	--	[illegible]
Renton Area (King) 0-3000	--	--	--	45.[illegible]
Tiger Mountain (King) 0-3000	--	--	--	6
Hiblock (King) 0-3000	--	--	--	37
Washington - Green River[1,100]				
Green River (King) 0-3000 Also listed as Black Diamond - Ravensdale with [illegible] tons.	-	--	--	359.[illegible]
Washington - Wilkeson - Carbonado[1,100]				
Wilkeson - Carbonado (Pierce) 0-3000	--	--	--	2[illegible]
Washington - Whatcom County[1,100]				
Whatcom County (Whatcom) 0-3000	--	--	--	31[illegible]

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]
(millions of short tons @ feet of overburden)

State, Region, Deposit and (Counties)	Measured	Indicated	Measured and Indicated	Inferred
Washington - Centralia - Chehalis[1,95,100]				
Centralia-Chehalis (Lewis and Thurston) 0-3000	--	--	--	5,934
Washington - Fairfax - Ashford[1,95,100]				
Fairfax - Ashford (Pierce) 0-3000	--	--	--	64
Washington - Morton[1,100]				
Morton (Lewis) 0-3000	--	--	--	440
Washington - Skagit County Area[1,100]				
Skagit County (Skagit) 0-3000	--	--	--	507
0-3000 Totals	--	--	--	6,945
Wyoming - Powder River Basin[98]				
Spotted Horse (Campbell and Sheridan) 0-3000	--	2,325.23	--	3,581.48
Sheridan (Sheridan) 0-3000	397.81	2,333.05	--	13,567.49
Sussex (Johnson) 0-3000	--	595.02	--	233.44
Gillette (Converse) 0-3000	--	4,576.41	--	10,235.37
Powder River (Campbell) 0-3000	335.42	7,519.14	--	17,196.61
Buffalo (Johnson) 0-3000	--	1,401.80	--	1,380.76
Barber (Johnson) 0-3000	--	405.17	--	1,134.72

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]

(millions of short tons @ feet of overburden)

State, Region Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Wyoming - Powder River Basin (cont.)				
Lost Spring (Converse) 0-3000	--	577.75	--	597.74
Central Part of Basin 0-3000	--	--	--	9,717.08
Wyoming - Hams Fork Region[1,91]				
Kemmerer (Lincoln) 0-3000	731.17	3,346.38	--	364.97
Greys River (Lincoln) 0-3000	--	--	--	0.68
McDougal (Teton) 0-3000	16.61	89.19	--	19.75
Evanston (Uinta) 0-3000	--	793.28	--	15.29
Wyoming - Bighorn Basin[1,99]				
Meeteetse (Park) 0-3000	--	37.41	--	--
Oregon Basin (Park) 0-3000	--	23.86	--	35.10
Gebo (Hot Springs) 0-3000	23.86	--	--	--
Grass Creek (Hot Springs) 0-3000	--	39.82	--	4.93
Silver Tip (Park) 0-3000	--	17.30	--	4.66
Garland (Park) 0-3000	--	27.13	--	10.56
Basin (Bighorn) 0-3000	--	14.04	--	1.24
Southeastern (Washakie) 0-3000	--	37.20	--	51.24

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100] (millions of short tons @ feet of overburden)

State, Region Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Wyoming - Wind River Basin[1,99]				
Muddy Creek (Fremont) 0-3000	--	42.08	--	--
Pilot Butte (Fremont) 0-3000	--	0.16	--	--
Hudson (Fremont) 0-3000	21.71	37.[illegible]	--	--
Alkali Butte (Fremont) 0-3000	--	85.7[illegible]	--	[illegible].77
Tp. 33-34 N., R96W 0-3000	--	208.11	--	299.36
Powder River (Natrona) 0-3000	--	176.86	--	--
Wyoming - Black Hills Region[1,99]				
Cambria (Weston) 0-3000	11.88	10.01	--	14.63
Skull Creek (Weston) 0-3000	--	3.47	--	--
Sundance (Crook) 0-3000	0.56	--	--	--
Aladdin (Crook) 0-3000	0.59	--	--	--
Wyoming - Green River Region[1,99]				
Little Snake River (Carbon) 0-3000	--	1,174.94	--	763.99
Great Divide Basin Red Desert (Sweetwater and Carbon) 0-3000	--	732.60	--	547.28

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,9,88-100]
(millions of short tons @ feet of overburden)

State, Region Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
Wyoming - Green River Region (cont.)				
Rock Springs (Sweetwater) 0-3000	1,[illegible]	[illegible]	--	[illegible]
Wyoming - Hanna Field Outcrop Region[87]				
Hanna Field (Carbon) 0-3000	52.72	1,979.[illegible]	--	[illegible]
Wyoming - Southeast Region[1]				
Rock Creek (Albany) 0-3000	--	257.41	--	41.27
Wyoming - Northwestern Region[1,98]				
Jackson Hole (Teton) 0-3000	--	--	--	[illegible]
Wyoming - Southeastern Region[1]				
Goshen Hole (Goshen) Has never been estimated.	--	--	--	--
Wyoming - Powder River Basin[98]				
Little Powder River (Campbell) 0-3000	--	2,799.34	--	130.66
Pumpkin Buttes (Campbell) 0-3000	--	1,175.06	--	11,096.1
Dry Cheyenne (Converse) 0-3000	--	142.8	--	19.2
Glenrock (Converse) 0-3000	3.41	272.44	--	[illegible]
0-3000 Totals	1,621.9	40,372.8	--	77,[illegible]

Table A-1 (continued). COAL RESERVES BY OVERBURDEN THICKNESS[1,[illegible],88-100]

(millions of short tons @ feet of overburden)

State, Region Deposit and County(s)	Measured	Indicated	Measured and Indicated	Inferred
	All Western States			
0-100 Totals	--	43[illegible].8	--	--
0-150 Totals	33	15,994.1	1,024.7	7,[illegible]
[illegible]-250 Totals	65	--	1,352.8	1,[illegible]
0-200 Totals	11.1	7,[illegible].7	7,934	85,[illegible]
0-250 Totals	--	1,067.3	--	4,[illegible]
0-500 Totals	--	--	--	2,[illegible]
0-1000 Totals	1,[illegible]	[illegible]	4.7	63,985.4
1000-2000 Totals	[illegible]	777.2	--	18,304.8
0-2000 Totals	--	--	--	22,[illegible]
0-1500 Totals	33.7	77	--	[illegible]
[illegible]-3000 Totals	--	--	--	[illegible]
0-3000 Totals	3,[illegible]	48,[illegible]	27,208.[illegible]	248,70[illegible]
3000-4000 Totals	--	19.3	--	17,[illegible]
[illegible]-6000 Totals	--	--	--	47,[illegible]
0-6000 Totals	--	--	--	4,[illegible]
Total all categories	5,238.6	74,0[illegible]	37,125	470,677.[illegible]

APPENDIX B

WESTERN COALFIELD DESCRIPTIONS

The following is a state-by-state compilation of characteristics which define individual coalfields from a mining operations viewpoint. Typical quantities described in this section are:

1. Coalfield land area
2. Seam formation and thickness
3. Topographical layout
4. Strippable potential
5. Overburden characteristics
6. Overburden thickness
7. Mining problems
8. Mining activity to the present

The majority of information in this appendix is reproduced directly from the literature or quoted in summary form. A more comprehensive treatment of this subject can be found in various state reports and the 1974 Keystone Coal Manual. Refer to appendices A, C and G to obtain further data on individual coal deposits. Maps of the coalfields may be found in section 3.1 of the text.

Arizona

The following quote from the Bureau of Mines describes Arizona's strippable coal seams:

> Commercial seams lie in the Dakota and Mesa Verde formations of Cretaceous age. Seam thicknesses average between 4 and 22 feet, and for the most part, coal seams dip approximately 2°. Owing to the extreme lenticularity of individual seams, difficulty is encountered in seam correlation and estimation of the volume of resource.[2]

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Peirce describes all major coal areas and rank.[1] The Black Mesa Number 1 and Number 2 mines are currently producing strip coal.

> Although there are minor occurrences elsewhere, Arizona's principal coal-bearing region is Black Mesa, an area of approximately 3200 square miles in the Colorado Plateau portion of northeastern Arizona (Peirce and Wilt, 1970). Black Mesa is largely in Navajo County and is totally within the jurisdiction of the Navajo and Hopi Indian tribes. The Black Mesa Field, which contains Arizona's only known viable coal reserves, is coincident with the geomorphic feature called Black Mesa and covers about 2.8% of the land area of the state.
>
> The ranks of coals present in the Black Mesa Field have been reported variously, the variations ranging on either side of the line that separates subbituminous from bituminous coal. Jones (1972) states that Peabody's coal is bituminous and that one of their mines will average, on a dry basis, 12,325 Btu or more. Peirce and Wilt (1970), after summarizing all of the then available analyses, concluded that the coals of the Black Mesa Field are high volatile C bituminous. On the other hand, the U.S. Bureau of Mines (1971) classed Arizona's strippable reserves (actually Peabody's reserves) in the Black Mesa coalfield as subbituminous.

Colorado

A general coalfield description of Colorado coalfields is found below.[2] In general Colorado coal must be deep mined.

> Six counties of eastern Colorado (Adams, Arapahoe, Boulder, Elbert, El Paso, and Weld) in the Denver Basin have production records back to 1887. Desultory small-scale mining took place some years ago in underground and strip-mined areas where the coalbed is near the surface. The coal seams are lenticular and lignitic in some places about 15 miles east of Denver. These seams extend on a southward trend through Adams, Arapahoe, and Elbert counties. The most significant underground and strip mine production (until the latest close-down in 1963) was in the subbituminous coal near the terminus of that southward trend at Franceville. Here the coalbed flanks upward against the Rock Mountain uplift in the Colorado Springs coalfield of El Paso county.
>
> Owing to the hard sandstone that envelopes some Colorado coalbeds, particularly in the Western Plateau province, cutoffs used were a maximum of 50 feet of overburden or a 10-to-1 stripping ratio, a minimum coalbed thickness of 5 feet, a minimum of 12,000 Btu per pound of coal, and low sulfur content.

Individual Colorado coalfield descriptions are cited from Hornbaker and Holt.[1]

Durango Field

The Menefee Formation coals are high volatile A bituminous and high volatile B bituminous rank and are of coking quality in structurally affected areas near Durango. Only one of the four operating mines in 1971 was a strip mine. The coal was used for the Durango Electric Plant. 3'2" to 6'7" is the thickness of the coal. The deep mines are 3,000 to 6,000 feet deep.

Book Cliffs Field

Some high volatile B bituminous coal exists but most is high volatile C bituminous.

1. The "Anchor Seam" is 6'2" thick
2. The "Palisade Seam" is 2'8" to 9'4" thick
3. "Carbonera Seam" is 7'6" to 8'6"

Book Cliffs field occupies 800 square miles. One mine was in operation in 1971.

Grand Mesa Field

The coal is subbituminous A to high volatile C bituminous and is 4.5 to 14 feet thick. It occupies 550 square miles. Two mines were worked in 1971, one a strip mine.

Tongue Mesa Field

Near the top of the mesa is a 900-foot thick coal-bearing section with an easterly dip of 2 degrees. The Cimarron seam is 8 to more than 40 feet thick. The coal is subbituminous B and is difficult to get to.

Somerset Field

The coal is high volatile B bituminous coal and high volatile C bituminous, produced by 4 mines. The field occupies 220 square miles.

1. Bowie Shale "lower group" coals:
   6.5 to 17.7 feet
2. Paonia Shale "upper group" coals:
   12 to 13 feet thick

Crested Butte Field

The coal is high volatile B bituminous and high volatile C bituminous and is of good coking quality with a thickness of 2 to 9 feet with a maximum of 14 feet. There are 6 seams. The field is 240 square miles to depths of 6000 feet. One small mine was in operation in 1972.

Carbondale Field

The southern half of the field is metamorphosed to high volatile A bituminous coal and non-coking. The seams are 4 to 11.5 feet thick. They cover

165 square miles with depths up to 6,000 feet. There were 4 mines operating in 1972.

Grand Hogback Field

The southern part is high volatile B bituminous coal and the northern is high volatile C coal. The seams range in thickness from 3.5 to 18 feet. The field covers 165 square miles with coal at 6,000 feet.

Danforth Hills Field

The seams range in thickness from 4 to 34 feet thick with high volatile C bituminous coal and all of it is non-coking. The field covers 340 square miles to depths of 6,000 feet. No railroads serve the area and development is limited. One mine was worked in 1972.

Lower White River Field

Seams are 8 to 12 feet thick and are primarily high volatile C bituminous coal. The field occupies 930 square miles.

Yampa Field

Yampa Field is well serviced by railroads. The seams are 3 to 23 feet thick and rank ranges from high volatile C bituminous coal to anthracite coal. The field is 1680 square miles and the deepest mine is 3,000 feet. Up to 70 mines have been in operation, but only 7 were worked in 1972.

Walsenburg Field

The seams are 3 to 7 feet thick and are high volatile B bituminous coal and high volatile C bituminous coal, non-coking. The area of the field is 220 square miles. The deepest mine worked was 3,000 feet. Ninety mines have operated in the area, the last in 1972.

Trinidad Field

The coal is high volatile A bituminous with some high volatile B bituminous and all is cokeable. The seams are 4 to 9 feet thick. The area is 890 square miles with the deepest mines at 3,000 feet. There have been 141 mines in 14 minable seams.

Cannon City Field

The coal is high volatile C bituminous coal, non-weathering, nonagglomerating and non-coking. The seams are 3 to 10 feet thick. There are 16 seams but only 7 are of any commercial importance. There have been 70 mines worked but only a few are operational now. Some strip mining is done. Four hundred fifty square miles of land is minable with the deepest mine at 2,000 feet.

South Park Field

The coal is subbituminous A and subbituminous B. It covers an area of 20 square miles. No reserve estimates were performed below 3,000 feet. Some mining was done around 1900. It was difficult due to weathering and dips to 45°. There are 7 or 8 flooded old mines.

North Park Field

In the Northeastern part seams are 10 to 58 feet thick. Dips range from 20° to 85°. In the southeastern part seams are about 20 feet thick with one 22 to 77 feet. Dips run from 10° to 20°. Eight hundred square miles are minable down to depths of 3,000 feet. There are a few mines in the area.

Middle Park Field

Very limited exploration has revealed no minable seams of coal but the possibility of appreciable resources exists in an area of about 270 square miles of the Middle Park Formation. There is no satisfactory basis for an estimate of resources.

Colorado Springs Field

The seams range between 5 and 17 feet and are subbituminous C coals. There is about 2,900 square miles of coal land. No mining is done presently.

Boulder-Weld Field

The seams are 4 to 14 feet thick with subbituminous B and C coal. Shaft mining predominates over drifts or slopes. Depth of the shafts range from 250 to 450 feet. The field is 1525 square miles.

Montana

The Bureau of Mines considers Montana coals to be of major importance in the development of the western coal industry. A summary of general characteristics of Montana fields is found below.[2]

> Strippable deposits of lignite and subbituminous coal in the eastern part of Montana lie in the Tongue River member of the Tertiary Fort Union Formation. Most of the resources are in beds 20 to 30 feet in thickness; however, seam thicknesses range upward to 85 feet.

Matson describes the characteristics of individual coalfields.[1] Coalfields cover about 35% of the land area of the state of Montana.

Decker Coalfield

Three minable coal beds underlie the area. The Anderson and Dietz coal beds range in thickness from 20 to 89 feet. Ash content averages 3.5% and sulfur content is 0.4%. The field covers 39.8 square miles.

Hanging Women Creek Coalfield

Two beds are in this field. Anderson bed ranges from 20 to 35 feet thick while Dietz is from 12 to 14 feet thick. Ash content is 6.4%. Sulfur averages 0.3%. The field covers 122.2 square miles.

Moorhead Field

Three beds occupy this field. Anderson bed has a thickness of 14 to 30 feet, Dietz bed ranges from 6 to 11 feet thick, and Canyon ranges from 7 to 25 feet thick. Ash content is 5.3%. Sulfur content is 0.3%. The field covers 77.5 miles.

Poker Jim Lookout Field

Anderson and Dietz beds range from 15-58 feet thick. Ash is 5.7%. Sulfur content is 0.4%. The field is 13.2 square miles.

Roland Field

The Roland bed is 10 feet thick. Ash content is 5.6%, and sulfur content is 0.3%. Roland field covers 27.8 square miles.

Squirrel Creek Field

Roland bed is 10 feet thick. Ash content averages 5.6%. Sulfur averages 0.3%. Squirrel Creek field covers 11.5 square miles.

Upper Rosebud Field

This field contains the Smith, Anderson, Canyon, and Wall coal beds. Anderson bed's thickness is 20 feet. Upper Rosebud Field covers 9.7 square miles.

Birney Field

The Brewster-Arnold coal bed, which averages 18 feet in thickness, is in Birney Field. The field covers 18.9 square miles.

Canyon Creek Field

The wall coal bed has a thickness of 60 feet in the Canyon Creek area. Canyon Creek Field covers about 4.4 square miles.

Poker Jim O'Dell Field

The Knoblock bed has two benches having a combined thickness ranging from 10 to 40 feet. This field covers 25.2 square miles.

Otter Creek Field

In this field, the Knoblock bed ranges from 20 to 60 feet in thickness. Otter Creek Field covers 31.7 square miles.

Ashland Field

In the Ashland Field, the Knoblock bed ranges in thickness from 25 to 70 feet. This field is 42.7 square miles in area.

Cook Creek Field

The Sawyer coal bed in this field has a thickness ranging from 8 to 12 feet. Cook Creek Field covers 4.7 square miles.

Beaver Creek Field

In the Beaver Creek Field, the Knoblock bed ranges from 12 to 22 feet in thickness. Beaver Creek Field has an area of 8.3 square miles.

Liscom Creek Field

The Knoblock coal bed has an average thickness of 8 feet. The field covers 8.3 square miles.

Miller-Greenleaf Creek Field

The Knoblock coal bed is about 22 feet thick and the Rosebud bed averages 12 feet thick. Miller-Greenleaf Creek Field covers 12.4 square miles.

Sweeney-Snyder Creek Field

The Terret coal bed averages 18 feet in thickness. The field has an area of 16.4 square miles.

Colstrip Field

Rosebud coal bed averages 25 feet in thickness here. Colstrip Field covers an area of 51.3 square miles.

Sarpy Creek Field

In Sarpy Creek Field are parts of the Rosebud and McKay coal beds, each as much as 35 feet thick with a minimum of 10 feet thick. Sarpy Creek Field has an area of 66.2 square miles.

Fire Creek Field

Pawnee coal bed is 16 to 20 feet thick. Fire Creek Field covers 2.0 square miles.

Upper Cache Creek Field

Pawnee bed averages 20 feet in thickness. The field has an area of 1.7 square miles.

Lower Cache Creek Field

The Broadus coal bed has an average thickness of 12 feet. The field has an area of 0.7 square miles.

Sonnette Field

Pawnee, average thickness of 20 feet, Cook, Sawyer, and Perry coal beds are in Sonnette. Sonnette is 9.1 square miles in area.

Pumpkin Creek Field

Sawyer bed averages 30 feet in thickness. The field covers 65.5 square miles.

Broadus Field

The Broadus bed ranges from 5-26 feet in thickness. Broadus Field covers 29.5 square miles.

Sand Creek Field

The Knoblock coal bed has a thickness ranging from 15 to 32 feet. Sand Creek Field has 9.3 square miles of area.

Foster Creek Field

The Knoblock bed is between 8 and 16 feet thick. Foster Creek Field covers 90.6 square miles.

Pine Hills Field

The Dominy coal bed has an average thickness of 17 feet. Pine Hills Field covers 14.1 square miles.

Lame Jones Field

The Dominy ranges in thickness from 6 to 10 feet. Lame Jones has an area of 16.6 square miles.

East Moorhead Field

The Cache bed ranges from 9 to 26 feet thick. The field has an area of 25.0 square miles.

Knowlton Field

The Dominy coal bed ranges from 8 to 31 feet in thickness. Knowlton has an area of 24.0 square miles.

Redwater River and Weldon-Timber Creek Field

S coal bed ranges in thickness from 8 to 12 feet. Redwater River covers 37.8 square miles and Weldon-Timber Creek covers 40.0.

Bull Mountain Coalfield

The coal in this field is in the Tongue River Member of the Ft. Union formation. The Tongue River Member has a thickness of 1700 feet and contains 26 persistent coal beds. Most of the coal mined comes from the Roundup coal bed, which is 500 feet above the base of the Tongue River Member and is 4 to 6 feet thick. The Carpenter bed, 5 to 8 feet thick, and the Mammoth bed, 5 to 14 feet thick in the Charter strippable field have some potential.

Red Lodge Coalfield

The Fort Union beds dip steeply at Red lodge and begin to flatten out at Bear Creek. The eight major coal beds in the Red Lodge coal field range in thickness from 3-1/2 to 10 feet, and each has produced some coal. The coal ranks as high-volatile C bituminous. Closely related to the Red Lodge coalfield are the Bridger, Silvertip, and Stillwater fields, but in those fields the coal is in the Eagle Sandstone. Late Cretaceous coal is in the Bridger coalfield, only one bed 2-1/2 to 6 feet thick, is workable. This bed has been mined in the Joliet, Fromberg, and Bridger areas. At the Silvertip field, two coal beds occur in the Eagle Sandstone and have approximately the same quality as the coal in the Bridger field.

Great Falls-Lewistown Coalfield

This field contains coal in the Morrison Formation of Jurassic age. Coal is high-volatile B and C bituminous. Thickness of coal is erratic with a maximum of about 18 feet.

North Central Region

The coal in the North Central region is in the Eagle Sandstone (Upper Cretaceous), and is ranked as subbituminous. Coal is also found in the Judith River Formation along the Missouri River, where the coal beds range from 2-1/2 to 7 feet in thickness. The rank and quality are similar to those of the coal in the Eagle Sandstone, but most of the Judith River coal is impure.

Blackfoot-Valier Region

The coal in the Blackfoot-Valier field is in the St. Mary River Formation and in the lower part of the Two Medicine Formation both of (Upper Cretaceous) age. The coal is relatively thin in this area, ranging in thickness from 20 to 36 inches.

Electric Field

The Electric Coalfield occupies a small area in the southwestern part of Park County. Thickness of the coal ranges from 3 to 5 feet, and the rank ranges from high-volatile A to low-volatile bituminous, depending on location.

Livingston-Trail Creek Field

Livingston-Trail Creek field is in Gallatin and Park counties. The three or four coal beds are in Upper Cretaceous rocks and range from 2 to 5 feet in thickness. Rank of the coal ranges from high-volatile A bituminous to C.

Lombard Field

The Lombard, in northern Gallatin county and southern Broadwater county, is about 6 square miles in area. Total thickness of coal is 6 feet. The coal is in the Morrison Formation. It varies in rank in proportion to structural deformation, but most of it is medium-volatile B bituminous.

Flathead Field

Coal in the Flathead field, a small area in the northern part of Flathead county in an intermountain basin, is in Tertiary strata. The coal ranks as subbituminous and the maximum known thickness is 3 feet.

Western Tertiary Fields

Numerous parts of the western Montana intermountain basins contain coal in beds of diverse thickness and areal extent. These coals are Tertiary in age and generally rank as subbituminous. Thickness as great as 25 feet has been reported.

New Mexico

A brief description of strippable coal reserves of New Mexico as reported by the Bureau of Mines is found below.[2]

> Strippable coal in New Mexico occurs as lenticular deposits in the Menefee, Crevasse Canyon, and Fruitland Formations of Cretaceous age. The coal seams dip gently eastward except at the extreme northern and southwestern fringes of the basin where strata are folded into prominent regional monoclines. Of the coal-bearing formations, the Fruitland offers the best prospects for abundant strippable coal. The best coal in Crevasse Canyon Formation is near Gallup where seams thicken and unite. Coal also appears in the overlying Menefee Formation. Else-

> where coal seams in the Crevasse Canyon and Menefee Formations are presumed to be thin, but too little is known to say definitely where strippable potential does or does not exist.

The following excerpts by Kottlowski and Shomaker describe fields in the San Juan Basin region.1

> The San Juan Basin Region is subdivided into 19 coalfields or areas covering over 26,000 square miles in northeastern New Mexico.
>
> Fruitland Field is currently being strip mined, with seams averaging 16 feet with a maximum of 50 feet and an overburden of less than 250 feet. The coal is high-volatile B bituminous coal and high-volatile C bituminous coal.
>
> Barker Creek, Hogback, and Toadlena Areas
>
> Small underground mines have been operated periodically for local use in the Hogback Field. Multiple coal beds occur in the Menefee in the Barker Creek Area. These are either involved in the Hogback monocline, where the seams dip too steeply to permit strip mining or they are overlain by thick beds of the massive Cliff House Sandstone. Thus, no strippable reserves have been calculated for this area. Similar seams occur in the upper and in the lower parts of the Menefee Formation in the Hogback Field. Locally these beds thicken

to 22 feet. The strata are structural to 38°. Thus, no strippable reserves were calculated. The coals are typically high-volatile B or C bituminous rank.

Navajo Field

Navajo Field is currently being strip mined with an overburden of less than 250 feet and an average of 120 feet. The coal is high-volatile B bituminous coal and high-volatile C bituminous coal. Coal seams average 4 to 10 feet thick.

Newcomb Field

Newcomb Field has reserves of strippable coal with less than 250 feet of overburden. Minable coal occurs in irregular thicknesses, 4 to 8 feet, and limited areal extent. The coal is subbituminous A or B.

Bisti Area

Bisti area is the largest underdeveloped strippable coal reserve and is about 35 miles long. This could be because of the limited transportation to the center of the San Juan Basin; only gravel and dirt roads reach the area. The overburden is shale and soft sandstone. Thus, strip mining would be inexpensive. The overburden is less than 250 feet thick. The coal is subbituminous A.

Star Lake Area

Star Lake area is about 55 miles long. The strippable coal is as much as 15.9 feet thick, but includes many thin partings of bone coal and shale. The overburden is less than 250 feet thick. Further exploration should reveal more coal than estimated.

Chaco Canyon and Chacra Mesa Area

Small drifts and pits operated by the Navajo Indians are the only mines. There are strippable reserves with 5 to 6 foot seams. There are other areas that are thin and overlain by a prohibitive thick overburden of Cliff House Sandstone. Recent work on the Menefee coals shows large reserves, but at depths below 500 feet.

La Ventana Field

La Ventana Field has small intermittent active underground mines. There are large accounts of reserves but due to 80° slopes and thick sandstone overburden in places, not all is strippable. Minable seams are 6 to 8 feet thick.

South Mount Taylor and East Mount Taylor Fields

Small drifts have been mined for local use. Thick volcanic sequence of Mount Taylor overlies most minable coal and prevents strip mining except in small areas. Minable coal ranges from 3.5 to 7 feet thick and is high-volatile C bituminous coal.

San Mateo Area

San Mateo area has strippable coal 3 to 6 feet thick with some area 12 feet thick. The overburden is less than 250 feet thick.

Standing Rock Area

No major reserves are evident from surface conditions, but analysis has shown that some areas are strippable.

Crownpoint Field

The coal is subbituminous A and subbituminous B coal and mined by the Navajo Indians in small drifts with seams 3.5 to 6 feet thick. Considerable deep reserves may be present.

Gallup Field

There was large scale underground mining, but most mining today is done by strip mining. The remaining strippable coal has an overburden of less than 250 feet and is high-volatile coal.

Zuni Field

This field is covered by Cenozoic volcanic rock and the out-cropping coal seams are thin. Considerable reserves of deep coal and of coal seams beneath thick sandstone are strippable.

Monero Field

In part of the field, on the backslopes of cuesta blocks, considerable strippable coal may be present, using geologic projection, but neither outcrops nor drill data are available. Beds as much as 7.3 feet thick have been mined, and the underground reserves should be considerable. However, dips of more than 5° and some faulting may make mining difficult. The coals are of high-volatile bituminous B or A rank.

Kottlowski and Shomaker describe fields in other parts of New Mexico.[1]

Tierra Amarilla Field

Most of the nine coal seams are thin and are overlain by excessive cover which includes massive sandstone. The coal is subbituminous A and is mined for local use only, with seams 9.6 feet thick. The coal is high-volatile C bituminous rank.

Cerrillos Field

The field is a complex syncline in which the coal-bearing rocks have been broken by many faults and have been intruded by swarms of dikes and sills.

Near thick igneous sheets, the coals have been metamorphosed to semianthracite and anthracite.

The coal-bearing strata are in the Mesaverde Formation; the major beds, ranging up to 6 feet in thickness, have yielded considerable tonnages of anthracite and bituminous coal.

Raton Field

The Raton Field in northeastern New Mexico lies on the western edge of the Great Plains in a rugged, dissected plateau country just east of the Sangre de Cristo Mountains. Many west to north-west-trending canyons reach into this plateau and provide easy access to the coal seams, which are almost horizontal drifts from the canyons. Only in a few localities is the overburden thin enough to allow strip mining, but considerable reserves can be strip mined. The York Canyon seam, which is 6 to 13 feet thick, is presently being mined. Most of coal seams are of high-volatile A to B bituminous coking coal. Mining has been essentially continuous in the field since about 1870.

Una del Gato Field

The Una del Gato Field lies in southeastern Sandoval county, in a dissected valley drained by Tonque Arroyo between the Sandia (north of) and Oritz Mountains. The coal seams are 3 to 5 feet thick, occur in the Mesaverde Group, are of high-volatile C bituminous rank, and are cut by numerous faults. Several small underground mines operated near Hagen in the 1900's but the field's remoteness and the difficulties of mining caused by the complex geologic structure stifled growth.

Tijeras Field

The coal bearing rocks are in the Mesaverde Group, and occur in a small down-dropped fault block, the Tijeras Graben. The strata are folded into two synclines and the intervening anticline, and dip steeply. Several thin beds of bituminous rank coal drop out, but only a few tons have been mined for local use.

Carthage Field

There are two seams ranging from 4 to 7 feet thick. Part of it is excellent coking coal of high-volatile C bituminous rank. This small field occupies about 10 square miles and is cut into a mosaic of small fault blocks, making mining difficult and expensive. Since 1950 only a single small underground mine has operated for local use only.

Jornada del Muerto

Windblown sand conceals much of the bedrock, the area is remote, and there has been no mining. The few outcrops are of coal similar to that mined in the Carthage Field, but maximum thicknesses are only 3 feet for coal outcrops. Drilling could find considerable reserves, as the Cretaceous strata extend for a length of at least 10 miles.

Engle Area

Prospect pits have opened thin lenses of coal and drill holes have penetrated several coal beds in the Mesaverde Group, but the apparent maximum thickness of coal seams is 2 feet. However, drilling is sparse and the Mesaverde Group strata do underlie 60 to 100 square miles near the railroad station of Engle.

Sierra Blanca Field

The seams are difficult to mine because the coal-bearing beds are broken by many faults and intruded by numerous igneous dikes and sills associated with the Sierra Blanca igneous complex. Outcrops of the coal-bearing strata form a broken semicircle on the west, north, and east sides of Sierra Blanca. Not much of the coal can be strip mined because of dips greater than 5° and excessive overburden. Most of the seams are of high-volatile C bituminous rank, and several are as much as 7 feet in thickness. Mining ceased in 1910 owing partly to the unusually large number of "rolls", lenses of sandstone that replace parts of the seams, which made mining expensive.

North Dakota

Coal mined in North Dakota has traditionally been surface mined due to the close proximity of coal to the surface and the relative ease with which overburden can be removed. Bureau of Mines describes North Dakota coals which are nearly 100% lignite as follows.[2]

> Lignite beds lie principally in the Tongue River Member of the Fort Union Formation of Tertiary age. They are essentially flatlying with dips of generally less than 1°. The beds range in thickness from a fraction of an inch up to 25 feet, and there are often two or more beds of minable thickness in a particular area.

North Dakota is broken into four districts in which the greater part of the commercial tonnage has been produced. Carlson describes commercially important deposits in these districts.[1]

> Noonan-Columbus District
>
> The Noonan-Columbus district is located in western Burke and eastern Divide counties, where the Noonan bed has been mined. This bed ranges from 7 to 10 feet in thickness with current operations limited to Burke county.
>
> Velva District
>
> The Velva district is located in eastern Ward county, where the Coteau bed is mined. The average thickness of this bed is twelve feet.
>
> Beulah-Zap District
>
> The Beulah-Zap bed is mined in the western Mercer county district at mines near Beulah and Zap. The bed originally extended over an area of approximately

500 square miles, from which a considerable area has been removed by erosion. The thickness ranges from 10 to 14 feet in the area where commercial operations are located. Thicknesses from about 18 to 22 feet have been reported to the north of these operations.

Hagel District

The Hagel bed is being mined in the Oliver-Mercer county district near Stanton in eastern Mercer county and near Center in Oliver county. In these areas the Hagel Bed ranges in thickness form about 8 to 22 feet of lignite with an intervening clay bed which varies from a few inches to as much as 6 feet thick.

In addition to these four districts the Lehigh bed, which is about 10 feet thick, is mined in Stark county for local use and to supply a briquetting plant at Dickinson. In Bowman county the Scranton bed has been mined on a small scale, but current development to supply a power plant in South Dakota will propel this area into a major producing area. Lignite is also mined for local use in a few counties of the field; the combined output of these small mines represents about 1% of the total production of the state.

Several other beds of potential importance have been identified by the United States and North Dakota Geological surveys, but no commercial

> developments have been undertaken due to the unfavorable location with reference to presently available water, transportation, and markets.
>
> The lignite beds are practically level and in most cases are covered with an impervious clay that has prevented weathering of the lignite even where the overburden is relatively shallow. These conditions favor strip mining methods, particularly where initial operations are on a scale to warrant installation of heavy stripping equipment. Preparation plants at commercial mines are of modern design. Because of the uniformity of the beds and freedom from partings and impurities, no cleaning plants are required.

Oregon

The following description of Oregon coalfields is reproduced entirely from Mason and Erwin (1955).[9]

> Much of the coal found in the state is poor in quality, and inability to compete with petroleum products and coal from other western states has greatly hindered mining development. Very little recent geologic work has been done in any of the coal-bearing areas except the Coos Bay region.
>
> Only the Coos Bay field is convenient to rail, highway, and ocean transportation. The other fields lie at some distance from highways and railroads.

Many of the coal deposits in Oregon are in forested or in partly inaccessible regions, and little is known about the extent of the deposits. Only about 600 square miles are underlain by known coal-bearing rocks.

The Coos Bay field is the only coal-bearing area that has consistently produced coal of commercial value. Although the other areas have produced coal for local consumption, mining operations have been limited because of the small quantity and poor quality of the coal, as well as the long haul to market.

However, most of the known coal-bearing beds in areas outside the Coos Bay field contain many partings of bone, carbonaceous shale, and clay, and are probably of sub-commercial value.

In the northern part of the Coast Ranges of Oregon the coal-bearing formations crop out along the flanks of the Coast Ranges anticline and the dip of the strata ranges from 15° to 30°. The coal-bearing formations throughout tne southern part of the Coast Ranges are folded into generally northward-trending anticlines and synclines in which the dip of the strata ranges from 5° to 40°. and locally is more than 40°.

The folds in the Coast Ranges are complicated by numerous high-angle faults which generally have northwest or northeast strikes. Displacements on these faults are usually small, but some can be measured in hundreds of feet.

Coos Bay Field

The Coos Bay field is located in the western part of Coos county, Oregon. It is elliptical, approximately 30 miles long and 11 miles wide, with an area of about 250 square miles. The topography of the field is characterized by a number of extensive sloughs tributary to Coos Bay and by flat-topped hills covered with brush and second-growth timber. The Coos and Coquille Rivers with their many tributaries drain the area.

The field is by far the most important in the state from the standpoint of production and reserves, and it is the only area in which coal has been produced.

The coal in the Coos Bay field is subbituminous B, subbituminous C, or lignite.

Eden Ridge Field

Throughout the region the beds dip at comparatively low angles. In the north the beds dip from 5° to 15° SW and in the west as much as 17° E.

The coal is high volatile bituminous C and occurs in rocks of the type formation of middle Eocene age. In a few localities the coal beds attain a maximum thickness of 9 feet; hwoever, the maximum thickness of coal generally is less because of the many shale and bone partings.

Rogue River Field

The coal is of a middle to early Eocene age and occurs in sandstones and shales of the Umpqua formation that have been covered by extensive lava flows. It is of subbituminous A or B rank and contains a large number of partings and bands of impurities.

Exploration has not been extensive enough to determine the geologic structure of the area, and the fact that the Eocene sedimentary rocks interfinger with lava flows makes it difficult to determine the extent of the coal beds. Diller (1909) noted that at most places in the field the beds dip gently northeastward and that the quality and quantity of the coal increases to the northeast.

There has been prospecting for coal throughout the area, and in many places the coal has been mined for local use. In the northern part of the field, on Evans Creek, beds as much as 8 feet thick have been found, but the coal contains a number of clay and sandstone partings. The coal found in the central part, although of better quality, is generally less than 1 foot thick. The coal found in the southern part is very thin and contains a large percentage of sulfur.

Eckley Area

The area is located near the Sixes River in a heavily timbered mountainous area, about 45 miles south of the Coos Bay field. The coal in the area is high-volatile C bituminous and occurs in rocks of the Arago group of Eocene age. The coal-bearing strata consist of shale and soft sandstone that have a thickness of approximately 50 feet and are exposed in only a few places. Where observed, the beds are folded and faulted. The thickness of the coal beds differ greatly from place to place and as a result of folding and faulting the coal occurs locally in irregular masses. The coal contains many layers of carbonaceous shale. There has been no production of coal from this area.

John Day Basin Area

Bituminous coal, subbituminous coal, and some lignite occur in the Mascall formation of Miocene age. Most of the coal is impure, however, and yields low Btu values. The coal ranges in thickness from a few inches to about 3 feet. The rocks enclosing the coal beds are composed largely of tuff with interbedded flows of andesite and other igneous material. The rocks have been highly faulted and folded, making it impossible to trace the coal outcrops for any distance.

Other Coal-Bearing Areas

Other small areas of coal-bearing rocks in Oregon have been described. In northwestern Oregon, coal has been found in Multnomah, Marion, Clackamas, Lincoln, Columbia, Yamhill, Clatsop, and Tillamook counties. The coal in these counties is subbituminous and occurs in rocks of Oligocene and late Eocene age. The largest area known to contain coal in this part of the state included about 20 square miles on the upper Nehalem River in Columbia county (Diller, 1895). The coal beds are from 1 to 10 feet thick, but the thicker beds consist mostly of carbonaceous shale. Coal has been found in an area of about 10 square miles in the west-central part of Lincoln county, but the thickest bed reported from this area contains only 3 feet of impure coal. Coal also occurs in southern Clatsop county in the lower Nehalem River area, but no bed thicker than 22 inches has been reported. In southwestern Oregon, near Comstock in the north-central part of Douglas county, thin impure coal beds occur in the Spencer Formation of late Eocene age. Small outcrops of subbituminous coal are also found in the Lookingglass and Camas Valley districts, and on Little River, all in Douglas county. A small amount of lignite occurs in the northeastern part of Malheur county in the eastern part of the state. Little is known about the coal deposits in any of these areas because the exposures and prospecting have not revealed coal that is promising enough to encourage commercial development.

South Dakota

South Dakota lignite production reached a peak of 71,000 tons in 1941. However, production has declined to a few thousand tons in recent years. Lignite has been used locally for fuel, and production from some beds has been treated for the recovery of uranium. Noble describes the general character of South Dakota coalfields.[10]

> In South Dakota's northwestern corner, about 7,000 to 8,000 square miles are underlain by rocks that in places are potentially coal-bearing. Erosion has removed a large fraction of the beds that were correlative with the productive lignite beds. A small amount of South Dakota's coal is of low sulfur subbituminous grade, but it is not commercially important. Outlook for exploitation looks bleak, at least for the next few years. The state has had no significant commercial production since 1968, nor have the exciting developments in the neighboring states been duplicated in South Dakota. Extremely sparse population in the coal area and the long distances to potential markets are deterrents to development. Also a deterrent is the fact that neighboring Wyoming, North Dakota and Montana have vastly greater reserves. Moreover, water is scarce, coal is relatively thin and lenticular, and there is no railroad through the heart of the coal area. Although Rapid City, South Dakota, is the site of a pilot plant for research in gasification, it is not likely that full-scale gasification plants will be constructed in the state in the near future.

Utah

Bureau of Mines describes the strippable coal found in Utah as follows.[2] Most coals in Utah, however, are deep minable only.

> Deposits near Alton in the Kanab Field in the southwestern part of the state appear favorable for large-scale strip mining. However, markets must be established before the deposits can be developed. Water supplies near these reserves appear inadequate for the development of mine-mouth electric generating facilities. The Kanab coalfield contains the largest known reserves of strip coal in the state. These occur in one of two prominent coalbeds in the Cretaceous Tropic Formation. The upper coalbed is about 400 feet above the lower and is considered strippable where overburden is 10 to 60 feet. Average minable coal thickness of the upper seam is 11 feet.

Shepardson describes the Utah fields in the following excerpts from the Keystone Coal Manual.[1]

> Book Cliffs Coal Field
>
> Dips are generally 3° to 7° and in some areas up to 15°. The seams are generally 4 feet thick and 3000 feet deep. It is the leading producer in the state.

Book Cliffs coal is convenient to the mainline of the Denver and Rio Grande Western Railroad and could be moved to a site on the Green River (perhaps near the town of Green River, Utah) by rail or perhaps by slurry pipeline. It has been stated that water was available to satisfy the cooling needs of a thermal power plant with a generating capacity in excess of 2600 Mwe. It is possible that these two opportunities could be joined.

Sego Area

Sego area occupies 390 square miles. The field is dormant now because the principal market for this coal was the steam locomotive. The bulk of the reserves is in the Cretaceous Chesterfield Formation. The best coal is in the western area.

Wasatch Plateau Field

There are eight mines in operation with more being opened. There are over 20 beds with coal more than 4 feet thick. Mining problems in Wasatch Plateau field include thick overburden, faulting, burned coal, water problems, and others, all of which have been successfully overcome by operators, but these problems have forced the costs of extraction to about the $4.40-per-ton level (1973). Present-day activity in this coalfield was prompted by the recognition that a large supply of water would be impounded in the southern end at Lake Powell.

Emery Coalfield

The Emery Field occupies 210 square miles. Seams are 4 feet thick. Very general estimated mining costs range from $6 to $7 per ton for these underground seams (1973).

The Emery field, some time ago, was proposed as a potential power plant site. Any power plant sited here today and using present-day technology, would face high water-acquisition cost and quite likely some air pollution problems. The field may have eventual possibility as a gasification site.

Henry Mountain Field

This field covers 450 square miles with seams more than 4 feet thick at depths of 3,000 feet or less. The Emery seam is today the most clearly attractive and might eventually supply power plants possibly sited on the Fremont or Escalante rivers. The field contains some strip reserves, an unusual condition in Utah. However, the remoteness of the area and the uncertainty of the water supply suggest that development may be some time in the future.

Alton Field

This field is strippable with an overburden of less than 80 feet and thickness of 12-20 feet. The area is interesting since much strip overburden can be removed without blasting, and mining costs might consequently be below $2.50 per ton (1973).

Goose Creek Lignite Field

Goose Creek Lignite Field is far removed from the necessary water and transportation facility. Reserves are high in ash (ash contains occasional interesting uranium values), and are minable by underground methods. Goose Creek would not be economic in the foreseeable future, and operations are not now conducted there.

Lost Creek Coal Field

This field covers 6,400 acres with beds that are 4 feet thick. The area is not being mined presently.

Sevier-San Pete Field

This field covers 30 square miles with beds that are 4 feet thick. The area is not being mined now.

Salina Canyon Field

The field covers some 40 square miles and is estimated to contain about 85 million tons of coal in beds of 4 feet or more. Cover is 3,000 feet. Operations are not now being conducted here.

Wales Field

Wales field is not in operation now. It covers 5.5 square miles. The bed is 4 feet thick or more. Cover is approximately 3,000 feet.

Sterling Field

Sterling Field covers 2 square miles and is 4 feet thick with cover approximately 3,000 feet thick.

LaSal-San Juan Fields

Coal in this remote and arid region appears to be of academic interest only. Throughout the potential area of 17,000 square miles, exploration to date has established no reserves in beds over 4 feet in thickness.

Tabby Mountain Field

While water might be available to support a consuming plant, the low Btu of the coal, coupled with the steep dips (over 30°) of the beds frequently found, indicate that this field will not have much development in the near future.

Coalville Field

One mine, producing about 12,000 tpy, is operating at this time. The major seam is the Wasatch which is about 8 to 10 feet thick. This field will probably continue to serve small truck markets. However, only passable roof and floor conditions, steep dips in the beds, and the spontaneous combustion of the coal product suggest that markets will be quite limited.

Henry's Fork Field

All prospecting in this area appears to have occurred prior to World War I. While this field might be as long as 100 miles, width is probably no more than 1 mile. It is limited on its south side by severe faulting, occurring in the north flank of the Uinta Mountains. There appears to have been little or no production. At most, four mines may have operated in purely local markets. Rail transport is over 20 miles away. There is no present activity in the area and the field appears now to be of academic interest only.

Kolob-Harmony Field

There is no mine in operation. The field covers 384 square miles. Coal is quite variable in its characteristics throughout the field. A major technological shift must occur before this field becomes competitive.

Vernal Field

Beds are over 4 feet thick. There are moderate to steep dips. The beds are rarely over 5 feet thick and contain many splits. The Vernal field is situated in Uintah basin which is a well-watered area. Utah Power & Light and others are seeking water appropriation to support various plants. If the characteristics of the coal and the structural geology of the field can be economically overcome, this field should see later development.

Washington

The single most important deposit of strippable coal is northeast of Centralia in Lewis and Thurston counties. The deposit in the Centralia-Chehalis area contains the Big and Smith seams of the Skookomchuck Formation of late Eocene age. Over 90% of the strippable reserve is in the Big seam. Coalbed thicknesses range from 5 to 50 feet. Other coal areas of lesser interest are as discussed by Livingston.[1]

Whatcom County Area

This area covers 500 square miles. Some dips are as high as 60°. Seams average between 7 and 14 feet thick. Of special interest in Whatcom County, because it contains anthracite coal, is the Glacier field. For years operators have attempted to work this field, but to date all attempts have failed.

Skagit County Area

This coal area covers 700 square miles. The beds have been mildly to severely deformed and dip up to 70°. The analysis data is limited; the rank is bituminous.

Issaquah-Grand Ridge King County Area

This area is broken down into 6 areas:

1. Newcastle-Grand Ridge Area. Dips are generally 30° to 40° but increase to 75° in Grand Ridge Area. The coal beds are in nonmarine rocks of the Puget Group and are probably near the top of the Eocene section. The thickness of the beds ranges up to 17 feet.
2. Cedar Mountain Area. The coal is generally subbituminous to high-volatile C bituminous. Because of poor data, it has not been possible to correlate the seams with any degree of certainty from one side of the fault to the other.
3. Renton Area. Folding in the area has been moderate to intense with maximum dips reaching 65°. The coal is subbituminous A or high-volatile C bituminous. Seam thickness is 5 to 8 feet.
4. Tiger Mountain Area. The coal occurs in the rocks of Puget Group. The rocks have been folded and the beds strike northeast and dip about 45°. The coal is subbituminous B rank. The thickness is between 3 and 6 feet.
5. Niblock Area. Little is known about the geology of this area. The coal seams occur in the Puget Group but their stratigraphic position is not definitely known. The beds strike about north 45° west and dip up to 75° to the southwest. The coal is high-volatile A bituminous rank. Some coal has been mined.

6. Taylor Area. The coal beds crop out around the nose of a southeast-plunging syncline with dips ranging from 40° to 80°. The coal is high-volatile A bituminous and high-volatile B bituminous. There are ten beds with seams ranging from 3 to 5 feet.

Green River-King County Area

The coal-bearing rocks have been extensively folded into a series of north-to-northeast and northwest-tending anticlines and synclines. Some folds may have displacements of over 1,000 feet. The rank ranges from subbituminous B to high-volatile A bituminous; however, most of it is high-volatile B bituminous.

Wilkeson Carbonado-Pierce County Area

The rocks have been tightly folded into a series of north-northwest-plunging anticlines and synclines. Dips are moderate to high ranging from 30° to vertical. The seams range from 2 to 14 feet thick. The coal is ranked from low-volatile B to high-volatile A bituminous.

Fairfax-Ashford Area

The coal is in sedimentary rocks and the beds are intruded by igneous rock. Stratigraphic relations have not been determined yet. Dips in the area are usually steep, 60° and higher being quite common. The coal varies in rank from low-volatile B to high-volatile A bituminous and has coking qualities. Only limited production has been reported from the Fairfax Area and none from the Ashford Area. The seams are 3 to 14 feet thick.

Morton Area

Little is known about the geology of the coal seams. The coal seams dip steeply to the west along the west limb of a north trending anticlinal structure. The rank is mostly high-volatile bituminous. There are no reports of significant production.

Eastern Lewis County Area

The coal is in sedimentary rocks of Eocene age. The coal has been subject to such intense deformation that some of it is anthracite in rank; however, it is very bony and has a high ash content. There has been no production.

Kelso-Castle Rock Area

The coal rank is lignite to subbituminous B. No coal has been mined since 1890. The coal-bearing rocks in this area have been gently folded into broad open northwest-trending anticlines and synclines. Dips of the beds are low, rarely exceeding 25°. Faults are present but of small displacement.

Roslyn-Kittitas County Area

The coal rank ranges from high-volatile A bituminous to high-volatile B bituminous. The seam thickness ranges from 2 to 15 feet.

Taneum-Manastash Area

The rank is high-volatile A bituminous and no coal has been produced.

Wyoming

General characteristics of Wyoming's strip coal deposits are reproduced from the Bureau of Mines.[2]

> Coal-bearing strata are of Upper Cretaceous and Tertiary ages. The most significant strip-coal deposits are of Tertiary age in the northeastern part of the state; they include the 30- to 130-foot-thick Roland coalbed and the 10- to 40-foot-thick Felix coalbed. These two coalbeds crop out for more than 100 miles along the east flank of the Powder River Basin and contain a major part of the state's strippable reserves.

There are 10 major regions which underlie more than 40,000 square miles of the state of Wyoming. Most coal regions are strippable. A short description of the regions and their seams is listed below (Glass).[1]

Powder River Coal Basin

This basin covers over 12,000 square miles in northeastern Wyoming. Dips are usually less than 5° on the eastern side, steeper on the western side. Most of the coal is subbituminous C rank. Important coal seams in the Powder River Basin are as follows:

1. Badger Seam. The seam ranges between 17 and 20 feet in thickness. It is currently strip mined in Converse County. It is best developed in the Glenrock Field.
2. Canyon Seam. It is best developed in the Spotted Horse Field in portions of Campbell and Sheridan counties. Its thickness ranges from 11 to 20 feet. There are no active mines on this seam.
3. Carney Seam. This seam is well developed in Sheridan Field. In thickness it averages 15 feet and ranges between 7 and 20 feet. The Carney seam is not currently mined.
4. D Seam. This seam is important in the southern part of the Gillette Field, and averages 8 to 16 feet in thickness. Maximum thickness is 65 feet. The D seam is currently strip mined in Converse County.
5. E Seam. This seam underlies the D seam in the southern portion of the Gillette Field. It averages 5 feet in thickness. E seam is not being mined.
6. F Seam. The seam is well developed in portions of the Dry Cheyenne and Gillette Fields in Converse County. Bed F has a maximum thickness of 11.6 feet but averages only 7.5 feet. It is not currently being mined.
7. Felix Seam. The Felix seam is important in Spotted Horse Field in Campbell County.

It ranges between 5 and 21 feet in thickness with an average of 12.5 feet. The seam is not being mined.

8. Healy Seam. The Healy seam in the Buffalo Field in Johnson County ranges between 5 and 25 feet at outcrop, but is as much as 220 feet thick. It is not currently being mined.
9. Monarch Seam. This seam is the most important seam in Sheridan Field. Thickness ranges from 18 to 57 feet. The seam is strip mined in Sheridan Field.
10. School Seam. The seam is important in Glenrock Field of Converse County. The seam averages 35 feet in thickness and ranges from 22 to 48 feet. The seam is strip mined in Converse County.
11. Smith Seam. This seam is well developed in the Spotted Horse Field. It ranges between 5 and 13 feet in thickness. The seam is not being mined.
12. Sussex Field (lower bed). This "lower bed" in "Basin No. 4" of the Sussex Field averages 11.8 feet thick but reaches a maximum of 50 feet. There is currently no mining of this seam.
13. Wyodak Seam. It is best developed in the Powder River and Gillette Fields. The seam averages 71 feet thick but ranges between 55 and 106 feet thick. It commonly has an 8-inch parting 38 feet above its base. The seam splits into two separate seams to the west with the lower branch ranging between 22 and 35 feet in thickness. The interval

between the two benches goes up to 100 feet. To the north the seam splits into 5 or more beds varying from 5 to 31 feet in thickness and separated by 4 to 33 feet of clay and shale. The Wyodak seam is currently strip mined in Campbell County.

14. Roland-Smith Seam. See Wyodak seam.

Green River Region

The Green River Region covers about 15,400 square miles of southwestern Wyoming. It is divided into two major structural basins by the Rock Springs anticline: the Green River Basin to the west and the Great Divide Basin to the east. Dips in this region are small except around the Rock Springs uplift and the western margin. Dips on the western side of the Rock Springs Uplift go up to 20°, and on the eastern side 10°. Along the western margin of the region, dips range between 20° and 50° in some areas.

Coal ranges in rank from subbituminous C to high-volatile C bituminous. The higher rank coals occur on the eastern margins of the region as well as around the Rock Springs Uplift. Important coal seams in the region are as follows:

1. B and C Seams. These two unmined seams are subbituminous A coals of the Wasatch Formation and reach their maximum development in the northern part of the Little Snake River Field. The B seam ranges from 10 to 18 feet in thickness and normally has a 1- to 2-foot

parting in it. The C seam, which is 40 to 70 feet below the B seam, ranges in thickness between 20 and 32 feet. It has a 1- to 1-1/2-foot parting. In places these two seams coalesce into a single seam of 30 to 40 feet in thickness, which has a parting up to 4 feet thick.

2. Battle No. 1 and No. 2 Seams. These two subbituminous B coals outcrop in the southeastern part of the Great Divide Basin Field. They are seams of the Wasatch Formation. They average between 6.4 and 8.6 feet in thickness.
3. Creston No. 2 and No. 3 seams. These seams are in the Wasatch Formation in the Great Divide Basin Field. They outcrop in the southeastern part of the field where they average about 18 feet in thickness. They are subbituminous B in rank.
4. Hadsell No. 2 Seam. This is another Wasatch seam outcropping in the southeastern part of the Great Divide Basin Field. It is subbituminous B in rank and averages 7.7 feet thick.
5. Jim Bridger Seams. Two coal seams of the Fort Union Formation are exceptionally well developed on the western edge of the Great Divide Basin Field. These seams have been referred to as the Jim Bridger deposits. Each seam averages 15 feet thick, and where the two seams coalesce into a single seam, it is 30 feet in thickness. The seams are probably subbituminous in rank.

6. Latham No. 3 and No. 4 Seams. The Latham seams are best developed in the southeastern part of the Great Divide Basin Field. They occur in the Wasatch Formation and are subbituminous B coals. Average thickness is 5.7 feet.
7. Rock Springs No. 7 Seam. This seam averages 4.5 feet in thickness, is high-volatile C bituminous in rank, and occurs in the Rock Springs Formation of the Mesa Verde Group in the Rock Springs Field.
8. Rock Springs No. 11 Seam. The No. 11 seam is high-volatile C bituminous coal, ranges from 44 to 54 inches in thickness, and averages 4 feet thick. It is an important seam in the Rock Springs Field. This seam is in the Rock Springs Formation.
9. Sourdough-Monument-Tierney Seams. This group of coals is actually five seams that occur at about the same horizon in the Wasatch Formation in the southeastern part of the Great Divide Basin Field. Because at times these seams coalesce with one another, separation of the coals into individual beds is not always possible. In places, each of these subbituminous B coals exceeds 5 feet in thickness.

Hanna Field Region

Coal-bearing rocks of the Hanna Field outcrop in a 750 square mile area of Carbon County in south-central Wyoming. Most simply, the Hanna Field occupies a structural trough that is divided into two separate basins by a northeast-southwest trending anticline. The Hanna Basin lies to the northwest of the anticline while the Carbon Basin lies to the southeast. The Hanna Field is bounded on the north, west and south by mountain ranges. Faulting is common in the field.

Coal seams occur in the Mesa Verde Group and Medicine Bow formations of Upper Cretaceous age, the Ferris Formation of Upper Cretaceous and Paleocene age, and the Hanna Formation of Paleocene and Eocene age. The rank of the coals in the Hanna Field ranges from subbituminous C to high-volatile C bituminous. The highest ranked coal, high-volatile C bituminous, occurs in the Mesa Verde Group. Collectively, coals of this group and the Medicine Bow formation range downward in rank to subbituminous B. The Hanna Formation and Ferris Formation coals are predominantly subbituminous although the Hanna No. 2 seam of the Hanna Formation has reportedly been ranked as high as high-volatile C bituminous.

The important seams in the Hanna Field are as follows:

1. Bed No. 25. Bed No. 25 is a minable seam in the lower third of the Ferris Formation and is best developed on the west side of the Hanna Basin. The seam averages 22 feet in thickness and is of subbituminous rank. It is currently strip mined in Carbon County.
2. Bed No. 50. This coal seam occurs near the middle of the Ferris Formation and is subbituminous coal. The seam is best developed

in the Hanna Basin portion of the field. It averages 15 feet in thickness and has been strip mined in Carbon County.

3. Bed No. 50. This Ferris Formation coal is of Paleocene age. It is subbituminous in rank and is the only seam currently being deep mined in the field. The seam is important in the Hanna Basin and ranges from 6 feet to 8 feet in thickness. Its average thickness is 7 feet.
4. Bed No. 80. No. 80 is a Paleocene coal of the Hanna Formation. The rank is subbituminous. This seam is well developed in the Hanna Basin where it ranges from 15.5 to 24 feet in thickness. The No. 80 bed generally has a 1- to 1-1/2-foot parting 2 to 5 feet above its base. It is strip mined in Carbon County.
5. Bed No. 82. This seam is an Eocene coal in the Hanna Formation. It is subbituminous coal and averages 9 feet thick. It is best developed in the Hanna Basin and is strip mined in Carbon County.
6. Brooks Seam. This seam is a subbituminous Paleocene coal near the base of the Hanna Formation. It ranges between 8 feet and 15 feet in thickness and is strip mined in Carbon County.
7. Hanna No. 2 Seam. Although this seam is not presently being mined, it has been extensively deep mined and strip mined in the Hanna Basin. This coal is normally of subbituminous A rank, but in places it is ranked as high-volatile C bituminous. These higher ranked occurrences

are where the seam is not weathered. The Hanna No. 2 Seam ranges in thickness from 30 to 35 feet. The seam is usually divided into three benches by partings.

Hams Fork Region

This region is the westernmost of the coal-bearing areas. Because it is highly folded and thrust faulted, the coal-bearing rocks outcrop in long narrow belts. The coal-bearing rocks of this region are the Bear River, Frontier and Adaville formations of Upper Cretaceous age and the Evanston Formation of Paleocene age. Coals in this region range between high-volatile A bituminous and subbituminous B. Coals up to 20 feet thick occur in the Frontier Formation and are the higher ranking seams. The Adaville Formation coals are subbituminous B rank and attain thicknesses over 100 feet.

Adaville Seams

These seams are the most important coals in the region and are best developed in the Kemmerer Field. At least seventeen seams in this formation exceed 6 feet in thickness. The Adaville No. 1 seam is the thickest and attains thicknesses in excess of 100 feet. Some production of the No. 1 seam is used to make chemical coke for the phosphorous industry as well as experimental metallurgical grade coke. All the seams have partings which range from 1 inch to 15 feet in thickness. These coals are all subbituminous B in rank. All the current mining on these seams is by surface methods.

Bighorn Basin

The Bighorn Basin is a broad structural basin bounded on the east, south and west by mountain ranges. Coal-bearing rocks underlie about 4,400 square miles of the basin. They are exposed in the folded rocks around the margin.

In these folded edges of the Bighorn Basin, dips as steep as 50° are common.

Coals in the more central portion of the basin are under deep cover and little is known about them. Most of the coals are lenticular and of limited extent, especially along the eastern side. Thicker and more extensive coal seams occur on the southern and western sides.

Coal in the northernmost part of the Bighorn Basin is high volatile C bituminous in rank while the remaining part of the basin contains subbituminous A and B coals.

Gebo Field Seams (Uncorrelated)

One uncorrelated coal seam is currently mined in the Gebo Field. The seam ranges between 7 and 9 feet in thickness, but averages only 7 feet. The seam is mined underground by conventional methods.

Grass Creek Field Seam (Uncorrelated)

One uncorrelated seam in the Grass Creek Field is currently being deep mined by conventional methods.

The coal seam ranges from 20 to 50 feet in thickness and has been strip mined in the past.

Wind River Coal Basin

The Wind River Basin is a large asymmetrical syncline in central Wyoming. Dips are steeper on the northern side than on the southern. Many minor folds and a number of faults complicate the basin. Coal bearing rocks are the Cody Shale, Mesa Verde and Meeteetsee formations of Upper Cretaceous age and the Fort Union of Paleocene age. Coal-bearing rocks outcrop around the margins of the basin. Coals in the central part of the basin are under considerable cover. Coals are believed to be subbituminous.

Jackson Hole Coal Region

The Jackson Hole Field in northwestern Wyoming is underlain by minable seams over an area of 700 square miles. Minable coals occur in Upper Cretaceous, Paleocene and Eocene age rocks. The coal is probably subbituminous rank.

Black Hills Coal Region

The Black Hills Region is in the extreme northeastern part of the state. Coal outcrops in a narrow, discontinuous belt through the region. Minable coal is confirmed to the base of the Dakota Sandstone of Lower Cretaceous age. The field as a whole is usually considered to be "mined out." The coal in this field is high-volatile C bituminous and is a moderately good coking coal.

Rock Creek Coal Region

The Rock Creek Field is a small field southeast of the Hanna Field. Coal-bearing rocks occur in the Mesa Verde Group of Upper Cretaceous age and the Hanna Formation of Paleocene and Eocene age. The thickest and best exposed coal seams are in the northwestern part of the field. Coal in the field is subbituminous B rank.

Goshen Hole Coal Region

The Goshen Hole Field is in the southeastern part of the state. Coals in the field occur in the Lance Formation of Upper Cretaceous age. No coal more than 2.5 feet thick is known to exist in this field. The coal is probably of subbituminous rank.

APPENDIX C

WESTERN COAL PRODUCTION BY MINE FOR 1972 AND 1973 INCLUDING COALSEAM/ACTIVE MINE NOMENCLATURE ORGANIZATION

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Production data for 1972 and 1973 are compiled for the 10 western states included in this report. Oregon and South Dakota showed zero production for 1972 and 1973. The data for large mines (over 1 million TPY) in 1973 are presented in Table C-1. Table C-2 is a compilation of 1972 production data from the 1973 Keystone Coal Industry Manual. Table C-3 relates coalfields to active mines as of 1971 and seams worked in those mines.

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Table C-1. WESTERN COAL MINES
PRODUCING OVER ONE MILLION TONS PER YEAR IN 1973.[23]
(organized by overall U.S. size ranking)

Size Ranking[a]	Company	Name of Mine[b]	State	Production
1	Utah International	Navajo (S)	New Mexico	7,389,321
6	Western Energy Co.	Colstrip (S)	Montana	4,253,681
12	Peabody Coal Co.	Black Mesa (S)	Arizona	3,246,500
13	Washington Irrigation Dist.	Centralia (S)	Washington	3,229,176
18	Pacific Power & Light Co.	Dave Johnston (S)	Wyoming	2,897,383
20	Arch Minerals Corp.	Seminole No. 1 (S)	Wyoming	2,865,130
26	Kemmerer Coal Co.	Sorensen (S)	Wyoming	2,546,435
45	Peabody Coal Co.	Big Sky (S)	Montana	1,971,643
53	Knife River Coal Mining Co.	Beulah(S)	N. Dakota	1,726,000
67	Rosebud Coal Sales Co.	Rosebud 4A (S)	Wyoming	1,509,736
116	North American Coal Corp.	Indian Head (S)	N. Dakota	1,090,146
118	Pittsburgh & Midway Coal Mining Co.	Edna (S)	Colorado	1,076,120
131	Kaiser Steel Co.	Sunnyside No. 1 (D)	Utah	1,008,000
TOTAL				34,809,239
TOTAL WEST				58,000,000
% Production of Large Mines				60.0

[a] There were 4,879 coal mines operating in the U.S. in 1972.

[b] S = strip, D = deep

Table C-2. PRODUCTION DATA BY MINE FOR 1972[1]
(thousand short tons)

Company and City	Mine	County	Field	Type of Mine		
				Strip	Deep	Total
		Arizona				
Peabody Coal Co.	Black Mesa #1	Navajo	Black Mesa	2,951.6	0	2,951.6
			Total Arizona	2,951.6	0	2,951.6
		Colorado				
Bear Coal Co., Somerset	Bear	Gunnison	Somerset	0	193,331	193,331
C.F.&I. Steel Corp., Weston	Allen	Las Animas	Trinidad	0	616,327	616,327
Clayton Coal Erie	Lincoln	Weld	Boulder-Weld	0	327,028	327,028
Colowyo Coal, Craig	Red Wing	Moffat	Danforth Hills	0	135,992	135,992
Cooley Co., Florence	Cooley Strip	Fremont	Canon City	NA[a] 121,346	0 0	121,346
Cooley Co., Florence	Cooley 2 & 3	Fremont	Canon City	NA[a]	0	
Energy Fuels Corp., Steamboat Springs	Energy Strip #1	Routt	Yampa	769,277	0	769,277
Energy Fuels Corp., Steamboat Springs	Energy Strip #2	Routt	Yampa		0	
			Subtotal Colorado	841,273	1,272,678	2,113,951

[a] NA refers to individual mine tonnages not available

Table C-2 (continued). PRODUCTION DATA BY MINE FOR 1972[1]
(thousand short tons)

Company and City	Mine	County	Field	Type of Mine		
				Strip	Deep	Total
		Colorado (cont.)				
Imperial Coal, Erie	Eagle	Weld	Boulder-Weld	0	[illegible]	[illegible]
Mid-Continent Coal, Carbondale	[illegible]	Pitkin	Carbondale	0	NA[a]	NA[a]
Mid-Continent Coal, Carbondale	[illegible]	Pitkin	Carbondale	0	NA[a]	NA[a]
Mid-Continent Coal, Carbondale	Dutch Creek #1	Pitkin	Carbondale	0	[illegible] [illegible]	[illegible]
Mid-Continent Coal, Carbondale	Dutch Creek #2	Pitkin	Carbondale		NA[a]	NA[a]
Mid-Continent Coal, Carbondale	L. S. Wood	Pitkin	Carbondale	0	NA[a]	NA[a]
Peabody Coal Co., Nucla	Nucla	Montrose	Nucla-Naturita	[illegible]	0	[illegible]
Pittsburgh & Midway Coal Mining Co., Oak Creek	Edna Strip	Routt	Yampa	[illegible]	0	[illegible]
[illegible] Coal, Craig	Wise Hill #5	Moffat	Yampa	0	[illegible]	[illegible]
U.S. Steel Corp., Somerset	Somerset	Gunnison	Somerset	0	[illegible]	[illegible]
Western Slope Carbon Inc., Somerset	Hawks Nest #[illegible]	Gunnison	Somerset	0	[illegible]	[illegible]
			Total Colorado	[illegible]	[illegible]	[illegible]

[a] NA refers to individual mine tonnages not available.

Table C-2 (continued). PRODUCTION DATA BY MINE FOR 1972[1]
(thousand short tons)

Company and City	Mine	County	Field	Type of Mine Strip	Deep	Total
		Montana				
Decker Coal Co.	Decker No. 1	Big Horn	Decker	800.0	0	800.0 Note: Started production 8/22/72
Knife River Coal Mining Co.	Savage	Richland	Breezy Flat	320.975	0	320.975
Peabody Coal Co.	Big Sky	Rosebud	Colstrip	1,601.181	0	1,601.181
Western Energy Co.	Colstrip	Rosebud	Colstrip	5,500.7	0	5,500.7
			Total Montana	8,222.856	0	8,222.856
		New Mexico				
Kaiser Steel Corp.	York Canyon	Colfax	Ration	0	902.029	902.029
Pittsburgh & Midway Coal Mining Co.	McKinley	McKinley	Gallup	397.02	0	397.02
Utah International, Inc.	Navajo	San Jose	Fruitland	6,898.262	0	6,898.262
			Total New Mexico	7,295.282	902.029	8,197.311
		North Dakota				
Baukol Noonan Inc.	Baukol Noonan	Divide	Noonan	NA[a]	0	
			}	2,086.76		2,086.76
Baukol Noonan Inc.	Baukol Noonan #2	Divide	Noonan	NA[a]	0	
			Subtotal North Dakota	2,086.76	0	2,086.76

[a] NA refers to individual mine tonnages not available

Table C-2 (continued). PRODUCTION DATA BY MINE FOR 1972[1]
(thousand short tons)

Company and City	Mine	County	Field	Type of Mine Strip	 Deep	 Total
		North Dakota (cont.)				
Consolidation Coal Co.	Velva	McHenry	Velva	[illegible]	0	[illegible]
Consolidation Coal Co.	Glenharold	Mercer	Center	[illegible]	0	[illegible]
Husky Industries	No. 1	Stark	Dickinson	155,917	0	155,917
Knife River Coal Mining Co.	Beulah	Mercer	Beulah	[illegible]	0	[illegible]
Knife River Coal Mining Co.	Gascoyne	Bowman	Gascoyne	[illegible]	0	265,397
North American Coal Corp., Lignite Div.	Indian Head	Mercer	Beulah	[illegible]	0	[illegible]
			Total North Dakota	6,963,0[illegible]	0	[illegible]
		Oregon				
--	--	--	--	0	0	0
			Total Oregon	0	0	0
		South Dakota				
--	--	--	--	0	0	0
			Total South Dakota	0	0	0

Table C-3 (continued). PRODUCTION DATA BY MINE FOR 1972[1]
(thousand short tons)

Company and City	Mine	County	Field	Type of Mine Strip	 Deep	 Total
		Utah				
American Coal	Desert	Emery	Wasatch Plateau	0	426,944	426,944
Browning Coal Co.	Browning	Emery	Wasatch Plateau	0	126.0	126.0
Carbon Fuel Co.	Carbon Fuel	Carbon	Book Cliffs	0	327,725	327,725
Kaiser Steel Corp.	Sunnyside #1	Carbon	Book Cliffs	0	960,961	960,961
Kaiser Steel Corp.	Sunnyside #2	Carbon	Book Cliffs	0	95,160	95,160
Kaiser Steel Corp.	Sunnyside #3	Carbon	Book Cliffs	0	148,135	148,135
North American Coal Corp.	Castle Gate	Carbon	Book Cliffs	0	731,998	731,998
Peabody Coal Co.	Deer Creek	Emery	Wasatch	0	333,544	333,544
Plateau Mining Co.	Plateau	Carbon	Wasatch	0	310.0	310.0
Premium Coal Co.	Soldier Canyon	Carbon	Book Cliffs	0	107,418	107,418
Southern Utah Fuel Co.	Mine No. 1	Sevier	Salina Canyon	0	156,071	156,071
Swisher Coal Co.	Swisher	Carbon	Wasatch	0	268.0	268.0
United States Fuel	King Mine	Carbon & Emery	Wasatch	0	558,576	558,576
U.S. Steel Corp. Western District Coal Operations	Geneva	Emery	Book Cliffs	0	716.0	716.0
			Total Utah	0	4,755,154	4,755,154

Table C-2 (continued). PRODUCTION DATA BY MINE FOR 1972[1]
(thousand short tons)

Company and City	Mine	County	Field	Type of Mine		
				Strip	Deep	Total
		Washington				
Palmer Coking Coal Co.	Rogers	King	Green River	0	28,836	28,836
Washington Irrigation & Development Co.	Centralia Coal	Lewis-Thurston	Centralia	2,596,724	0	2,596,724
			Total Washington	2,596,724	28,836	2,625,56
		Wyoming				
Amax Coal Co.	Belle Ayr	Campbell	Gillette	32,957	0	32,957
Big Horn Coal	Big Horn	Sheridan	Sheridan	355.0	0	355.0
Arch Mineral Corp.	Seminoe #1	Carbon	Hanna	2,060,506	0	2,060,506
Arch Mineral Corp.	Seminoe #2	Carbon	Hanna	172,253	0	172,253
Energy Development Co.	Rimrock Strip Mine	Carbon	Hanna	852.3	0	852.3
Gunn-Quealy	Rainbow #7	Lincoln	Rock Springs	0	95,859	95,859
Gunn Quealy	Rainbow #8	Sweetwater	Rock Springs	0	4,710	4,710
Kemmerer Coal Co.	Elkol	Lincoln	Hams Fork	259,321	0	259,321
Kemmerer Coal Co.	Sorensen	Lincoln	Hams Fork	1,843,536	0	1,843,536
Pacific Power & Light Co.	Dave Johnston	Converse	Glenrock	2,618,137	0	2,618,137
			Subtotal Wyoming	5,733,768	100,569	5,840,337

Table C-2 (continued). PRODUCTION DATA BY MINE FOR 1972[1]
(thousand short tons)

Company and City	Mine	County	Field	Type of Mine		
				Strip	Deep	Total
		Wyoming (cont.)				
Resources Exploration Mining	[illegible] 1 & 2 Pit	Carbon	Hanna	525,138	0	525,133
Rosebud Coal Sales Co.	Rosebud	Carbon	Hanna	1,355.3	0	1,355.0
Wyodak Resources Development Corp.	Wyodak	Campbell	Little Powder River	822,620	0	822,620
Rocky Mt. [illegible] Coal Corp.				288,656	0	288,666
			Total Wyoming	11,531,176	100,585	11,631,761
			Total Western States	41,836,523	8,694,354	50,531,237

Table C-3. COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams^a	Active Mine	Type^b	Company
ARIZONA							
Black Mesa	Black Mesa	Navajo	17	Wepo #1	Black Mesa #1	S	Peabody Coal Co.
		Apache		Wepo #2	Black Mesa #2	S	"
		Coconino		Wepo #3			
				Wepo #4			
				Wepo #5			
				Wepo #6			
				Wepo #7			
				Wepo #8			
COLORADO							
San Juan	Cortez Dakota	Montezuma	17	Unnamed	--	--	--
San Juan	Durango	Archuleta	17	Hogback	--	--	--
		La Plata		Hesperus			
San Juan	Nucla-Naturita	Montrose	17	#1	Nucla Mine	S	Peabody Coal Co.
				#2			
				#3			
Uinta	Book Cliffs	Garfield	17	Anchor	--	--	--
				Cameo			
				Carbonera			
				Palisade			
Uinta	Grand Mesa	Delta	17	A	--	--	--
				B			
				C			
				D			
				E			
				F			
Uinta	Tongue Mesa	Delta	17	Cimarron	--		--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

Region	Field	County	District	Mines[a]	Active Mine	Type[b]	Company
Colorado (cont.)							
Uinta	Grand Hogback	Garfield	17	Black Diamond 4 6 7 1 1 1 Allen Anderson Wheeler Keystone #1 Keystone #1 Keystone #1 Keystone #1	--	--	--
Uinta	Danforth Hills	Rio Blanco	17	Black Diamond various	(1) Red Wing Mine	[illegible]	[illegible]
		Moffat		Fairfield various Lion Canyon various (1) Collom			
Uinta	Lower White River	Rio Blanco	17	--	--	--	--
Green River	Yampa	Routt	17	Bronze, Curtis #1 Pinnacle A Bear River, Sun Mine # Hubbard, Butcher Knife,		[illegible]	

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines

[b] S = strip mine, D = deep mine, C = captive mine

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Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]		Active Mine	Type[b]	Company
Colorado (cont.)								
Green River (cont.)				Rice Mine	C			
					D			
					E			
					F			
					G			
				Wolf Creek	H			
				(1) Wadge	I	(1) Seneca Mine	S	Peabody Coal Co.
				(2) Lennox	J	(1) Energy Mine	S	Energy Fuels Corp.
					K	(1)(2) Edna Mine	S	Pittsburgh & Midway Coal
				Crawford, Sleepy Cat	L	Wise Hill #1 Mine	D	[illegible] Coal Co.
				Corey	M			
					N			
					O			
					P			
				Dry Creek	Q			
					R			
					S			
				Lorella				
				Kimberly				
				Campbell				
				Seymour				
				Wasatch Seams				

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Colorado (cont.)							
Raton Basin	Walsenberg	Huerfano	17	Pamerson Lennox Walsen Pryor Lower Elkhorn Lower Rugby Upper Rugby Peterson Mutual	--	--	--
Raton Basin	Trinidad	Las Animas	17	Sorwell Raton Cameron Empire Walsen Hastings A, B Lower and Upper Robinson Hill Pryor Rapson Ludlow, Lower & upper (1) Cirucilla (Allen) Thomas Gem, Robinson, Peerless Piedmont Morley, Lower Starkville, Engleville Upper Starkville, Upper Morley	(1) Allen Mine	C,D	CF and I Steel Corp.

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seam[a]	Active Mine	Type[b]	Company
Colorado (cont.)							
Raton Basin (cont.)				Cokedale			
				Lower Sopris			
				Bear Canyon #1			
				Cass			
				Lower Rugby			
				Upper Rugby			
				Delagua			
				Bon Carbo			
				Frederick			
				Primero			
Canon City	Canon City	Fremont	17	Rockvale	(1) Curley Strip	S	The Curley Co.
				Canon City			
				Magnet			
				Radiant, Jack-O-Lantern			
				Royal Gorge, Gassick			
				Chandler, Littel			
				Brookside			
				(1) Black Diamond			
South Park	South Park	Park	17	lower	--	--	--
				middle			
				upper			
South Park	North Park	Jackson	17	Sudduth	--	--	--
				Lower Winscom			
				Upper Winscom			
				Coalmont unnamed #1			

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seam[a]	Active Mine	Type[b]	Company
Colorado (cont.)							
South Park (cont.)				Coalmont unnamed #[illegible]			
				Coalmont unnamed #[illegible]			
				Coalmont unnamed #[illegible]			
				[illegible]			
				Mitchell			
				[illegible]			
South Park	Middle Park	Grand	17	--	--	--	--
Denver Basin	Colorado Springs	El Paso	18	Laramie A	--	--	--
		Elbert		Laramie, [illegible] [illegible]			
		Douglas		[illegible], [illegible] [illegible]			
Denver Basin	Boulder Weld	Weld	16	Scranton	(1) Lincoln Mine	S	Clayton Coal Co.
		Jefferson		#1	(1) Imperial Mine	D	Imperial Coal Co.
		Boulder		#2	(1) Eagle Mine	D	Imperial Coal Co.
		Denver		Main Seam #1			
		Adams		#4			
		Arapahoe		Middle Seam #1			
				Upper Seam #1			
				#2			
				(1) Laramie #[illegible]			
Montana							
Fort Union	Decker	Big Horn	22	Anderson	(1) Decker #1 Mine	S	Decker Coal Co.
				(1) Dietz unnamed			
Fort Union	Hanging Woman Creek	Big Horn	22	Anderson	--	--	--
		Rosebud		Dietz			
		Powder River					

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[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Montana (cont.)							
Fort Union	Moorhead	Powder River	22	Anderson Canyon Dietz	--	--	--
Fort Union	Poker Jim Lookout	Powder River Rosebud	22	Anderson Dietz	--	--	--
Fort Union	Roland	Big Horn	22	Roland	--	--	--
Fort Union	Squirrel Creek	Big Horn	22	Roland	--	--	--
Fort Union	Upper Rosebud	Big Horn	22	Smith Anderson Canyon Wall	--	--	--
Fort Union	Birney	Rosebud	22	Brewster-Arnold	--	--	--
Fort Union	Canyon Creek	Rosebud	22	Wall	--	--	--
Fort Union	Poker Jim O'Dell	Rosebud	22	Knobloch	--	--	--
Fort Union	Otter Creek	Powder River	22	Knobloch	--	--	--
Fort Union	Ashland	Powder River	22	Knobloch	--	--	--
Fort Union	Cook Creek	Powder River	22	Sawyer	--	--	--
Fort Union	Beaver Creek	Powder River	22	Knobloch	--	--	--
Fort Union	Liscom Creek	Custer	22	Knobloch	--	--	--
Fort Union	Miller Greenleaf Creek	Rosebud	22	Knobloch Rosebud	--	--	--
Fort Union	Sweeney-Snyder Creek	Rosebud	22	Terret	--	--	--
Fort Union	Colstrip	Rosebud	22	(1) Rosebud	(1) Big Sky Mine (1) Colstrip Mine	S S	Peabody Coal Co. Western Energy Co.

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Montana (cont.)							
Fort Union	Sarpy Creek	Treasure	22	Rosebud	--	--	--
		Big Horn	22	McKay			
Fort Union	Fire Creek	Powder River	22	Pawnee	--	--	--
Fort Union	Upper Cache Creek	Powder River	22	Pawnee	--	--	--
Fort Union	Lower Cache Creek	Powder River	22	Broadus	--	--	--
Fort Union	Sonnette	Powder River	22	Pawnee	--	--	--
				Cook			
				Sawyer			
				Ferry			
Fort Union	Pumpkin Creek	Powder River	22	Sawyer	--	--	--
Fort Union	Broadus	Powder River	22	Broadus	--	--	--
Fort Union	Sand Creek	Custer	22	Knobloch	--	--	--
		Powder River					
Fort Union	Foster Creek	Custer	22	Knobloch	--	--	--
Fort Union	Pine Hills	Custer	22	Sonkey	--	--	--
Fort Union	Lame Jones	Fallon	22	Dominy	--	--	--
Fort Union	East Moorhead	Powder River	22	[illegible]	--	--	--
Fort Union	Knowlton	Custer	22	Dominy	--	--	--
Fort Union	Redwater River	McCone	22	?	--	--	--
Fort Union	Weldon-Timber Creek	McCone	22	?			
Fort Union	Breezy Flat	Richland	22	(2) Pust	(2) Savage Mine	S	Knife River Coal Mining Co.
Fort Union	Lamesteer	Wibaux	22	Harmon	--	--	--
Fort Union	Wibaux	Wibaux	22	?	--	--	--
Fort Union	Little Beaver	Wibaux	22	?	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Montana (cont.)							
Fort Union	Four Buttes	Wibaux	22	[illegible]	--	--	--
Fort Union	Hodges	Dawson	22	--	--	--	--
Fort Union	Griffith Creek	Dawson	22	--	--	--	--
Fort Union	Smith Dry Creek	Richland Wibaux	22	[illegible]	--	--	--
Fort Union	O'Brien-Alkali Creek	Richland	22	--	--	--	--
Fort Union	Burns Creek	Dawson	22	Pust	--	--	--
Fort Union	N.F. Thirteen Mile Creek	Dawson	22	Pust	--	--	--
Fort Union	Fox Lake	Richland	22	Lane	--	--	--
Fort Union	Carroll	Richland Dawson	22	Carroll	--	--	--
Fort Union	Fort Kipp	Roosevelt	22	Ft. Kipp Ft. Peck	--	--	--
Fort Union	Lanark	Roosevelt	22	Lanark	--	--	--
Fort Union	Medicine Lake	Sheridan	22	--	--	--	--
Fort Union	Reserve	Sheridan	22	--	--	--	--
Fort Union	Coal Ridge	Sheridan	22	Coal Ridge	--	--	--
Fort Union	Cheyenne Meadows	Rosebud	22	Knobloch	--	--	--
Fort Union	Charter	Musselshell	22	Mammoth	--	--	--
Fort Union	Little Wolf	Big Horn	22	Rosebud McKay McKay	--	--	--
Fort Union	Jeans Fork	Big Horn	22		--	--	--
Fort Union	Wolf Mountain	Big Horn	22	--	--	--	--
Bull Mountain	Bull Mountain	Musselshell Yellowstone	22	Roundup	--	--	--
Bull Mountain	Carpenter Creek	Musselshell	22	Carpenter	--	--	--
Bull Mountain	Charter	Musselshell	22	Mammoth	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine, D = deep mine, C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Montana (cont.)							
Red Lodge	Red Lodge	Carbon [illegible]	22	unnamed #1 unnamed #2 unnamed #3 unnamed #4 unnamed #5 unnamed #6 unnamed #7 unnamed #8	--	--	--
Red Lodge	Bridger	Carbon	22	unnamed #1	--	--	--
Red Lodge	Silvertip	Carbon	22	unnamed #1 unnamed #2	--	--	--
Red Lodge	Stillwater	Stillwater	22	--	--	--	--
Great Falls	Great Falls	Cascade	22	--	--	--	--
Lewiston	Lewiston	Judith Fergus	22	--	--	--	--
North Central	North Central	Liberty Hill Blaine Chouteau Fergus	22	Judith River	--	--	--
Blackfoot Valley	Blackfoot Valley	Glacier Pondera Teton Lewis & Clark	22	St. Mary River	--	--	--
Electric Field	Electric	Park	22	--	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine, D = deep mine, C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seam[a]	Active Mine	Type[b]	Owner
Montana (cont.)							
Livingston - Trail Creek	Livingston - Trail Creek	Gallatin, Park	22	Unnamed #1	--	--	--
				Unnamed #2			
				Unnamed #3			
				Unnamed #4			
Lombard	Lombard	Gallatin	22	Mountain	--	--	--
		Broadwater					
Flathead	Flathead	Flathead	22	--	--	--	--
Western Tertiary	Unnamed Tertiary	Granite	22	--	--	--	--
New Mexico							
San Juan	Fruitland	San Juan	18	Lower Full	--	--	--
				Upper			
San Juan	Navajo	San Juan	18	(1) #8	(1)Utah Int'l Navajo Mine	S	Utah International (Utah)
				(2) #			
				(3) #7			
San Juan	Bisti	San Juan	18	--	--	--	--
San Juan	Star Lake	San Juan	18	--	--	--	--
		McKinley					
San Juan	Gallup	McKinley	18	Cleary and Gibson Coals	(1)(2)(3)(4) McKinley Mine	S	Pittsburgh and Midway Coal Mining Co.
				(1) #1			
				(2) #2			
				(3) #3			
				(4) #4			
San Juan	Barker Creek	San Juan	18	--	--	--	--
San Juan	Hogback	San Juan	18	--	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
New Mexico (cont)							
San Juan	Fruitland	San Juan	18	--	--	--	--
San Juan	Newcomb	San Juan	17	--	--	--	--
San Juan	Chaco Canyon	San Juan	17	--	--	--	--
San Juan	Chacra Mesa	McKinley	17	--	--	--	--
San Juan	San Mateo	McKinley	18	Cleary Coals	--	--	--
San Juan	Standing Rock	McKinley	17	--	--	--	--
San Juan	Zuni	McKinley Valencia	17, 18	[illegible]	--	--	--
San Juan	Crownpoint	McKinley	17	--	--	--	--
San Juan	South Mount Taylor	Valencia	17	Gibson Coals Dilco Coals	--	--	--
San Juan	East Mount Taylor	Valencia McKinley	17, 18	Gibson Coals Dilco Coals	--	--	--
San Juan	La Ventana	Sandoval	18	Cleary Coals Allison Coals	--	--	--
San Juan	Monero	Rio Arriba	17	--	--	--	--
San Juan	Tierra Amarilla	Rio Arriba	17	--	--	--	--
San Juan	Rio Puerco	Sandoval	18	Dilco Coals Gibson Coals	--	--	--
Cerrillos	Cerrillos	Santa Fe	17	Willow Ranch Cook and White White Ash	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seam^a	Active Mine	Type^b	Company
New Mexico (cont.)							
Raton	Raton	Colfax	17	(1) York Canyon [illegible] Canyon Cottonwood Canyon Left Fork Yankee Tin Pan Vermejo Raton Chimney Rock	(1) York Canyon Mine	[illegible]	Kaiser Steel Corp.
Una del Gato	Una del Gato	Sandoval	13	--	--	--	--
Tijeras	Tijeras	Bernalillo	11	--	--	--	--
Carthage	Carthage	Socorro	13	Upper Carthage, Lower	--	--	--
Jornada del Muerto	Jornada del Muerto	Socorro	13	--	--	--	--
Engle	Engle	Sierra	17	--	--	--	--
Sierra Blanca	Sierra Blanca	Lincoln	18	--	--	--	--
Datil Mountain	Datil Mountain	Valencia Catron Socorro	17, 18	--	--	--	--
North Dakota							
Northwestern	Noonan-Kincaid	Burke	21	(1) Noonan-Kincaid	(1) Baukol Noonan Mine	S	Baukol Noonan Inc.
					(1) Noonan #2		Baukol Noonan Inc.
Southwestern	Slope	[illegible] Slope	21	[illegible] [illegible]	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State-Region	Field	Counties	District	Seams^a	Active Mine	Type^b	Company
North Dakota (cont.)							
Northwestern	[illegible]	Williams	11	#2 [illegible] [illegible] [illegible]	--	--	--
Northwestern	M and M	Williams	[illegible]	[illegible] [illegible]	--	--	--
Southwestern	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Southwestern	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--
Southwestern	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--
Southwestern	[illegible]	Mercer	[illegible]	[illegible]	--	--	--
Southwestern	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--
Southwestern	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]			
Southwestern	[illegible]	Mercer Oliver	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Southwestern	[illegible]	Oliver	[illegible]	[illegible] [illegible]	--	--	--
Southwestern	[illegible]	[illegible]	[illegible]	--	--	--	--
Southwestern	[illegible]	Williams [illegible] [illegible]	[illegible]	[illegible] [illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--

^{a}Numbers in parentheses refer to known seams actively mined by corresponding mines.

^{b}S = strip mine, D = deep mine, [illegible] = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mines	Type[b]	Company
North Dakota (cont'd)							
Southwestern	Bowman-Hettinger	Slope Stark	24	(8) Harmon	(9) Gascoyne Mine	1	Knife River Coal Min. Co.
Southwestern	New Leipzig	Grant Hettinger		--	--	--	--
OREGON							
Coos Bay	Coos	Coos	23	Beaver Hill [illegible] [illegible] [illegible] [illegible]	[illegible] [illegible] [illegible] [illegible]	[illegible] [illegible] [illegible] [illegible]	[illegible] [illegible] [illegible] [illegible]
Eden Ridge	Eden Ridge	Coos Curry	23	[illegible] [illegible] [illegible] [illegible]	--	--	--
Rogue River Shasta	Rogue River Shasta	Jackson Coos Curry	23 23	-- --	-- --	-- --	-- --
John Day Basin	John Day	Grant Wheeler Gilliam Morrow Umatilla	23	--	--	--	--
SOUTH DAKOTA							
Upper Northwest	--	--	--	--	--	--	--

[a] Numbers in parentheses refer to known seams actively mined by corresponding mines.

[b] 1 = strip mine; 2 = deep mine; 3 = captive mine.

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Utah							
Southwestern	Alton	Kane Garfield	20	Smirl Bald Knoll	--	--	--
Southwestern	Kaiparowits Plateau	Kane Garfield	20	Christensen Alvey [illegible]	--	--	--
Southwestern	Kolob-Harmony	Iron Washington Kane		Lower Upper	--	--	--
Central	Mt. Pleasant	Sanpete	20	unnamed	--	--	--
Central	Salina Canyon	Sevier	20	(1) Ivie	(1) Mine #1	U	Southern Utah Fuel Co.
Central	Sterling	Sanpete	20	--	--	--	--
Central	Wales	Sanpete	20	--	--	--	--
Central	Wasatch Plateau	Carbon Emery Sanpete Sevier	20	(1) Hiawatha (2) Castlegate "A" (3) Blind Canyon Bear Canyon [illegible]	[illegible] Mine [illegible] Mine Browning Mine (3) Deer Creek Mine (1) Plateau Mine (1) [illegible] Mine (2) King Mine	U U U U U U U	American Coal Co. American Coal Co. Browning Coal Co. Peabody Coal Co. Plateau Mining Co. [illegible] Coal Co. United States Fuel Co.
Central	Book Cliffs	Carbon Emery	20	Sunnyside (1) Castlegate "B" Kenilworth [illegible] Rock Canyon	(2)(1) [illegible] Fuel Mine (3) Sunnyside #1 Mine (3) Sunnyside #2 Mine (3) Sunnyside #3 Mine (2)(1) Castlegate Mine	U U, C U, C U, C U	Carbon Fuel Co. Kaiser Steel Corp Kaiser Steel Corp Kaiser Steel Corp [illegible] Coal Co.

[a] Numbers in parentheses refer to seams being actively mined by corresponding mines.

[b] S = strip mine, U = deep mine, C = captive mine.

Table C-3 (continued). COALFIELD IDENTIFICATION

State-Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Utah (contd.) Central	Book Cliffs (contd.)			(1) Lower Sunnyside (2) Castlegate Sub 1 (3) Upper Sunnyside (4) [illegible] (5) [illegible]	(1) [illegible] Mine (2) Geneva Coal Mine	2 2, 3	[illegible] U.S. Steel Corp.
Central	Emery	Emery Sevier	[illegible]	[illegible]	--	--	--
Eastern and Southern	Vernal	Uintah	[illegible]	[illegible] [illegible]	--	--	--
Eastern and Southern	Henry Mountains	Wayne Garfield	[illegible]	[illegible] [illegible] [illegible]	--	--	--
Eastern and Southern	Sego	Uintah Grand	[illegible]	Palisade Ballard Chesterfield Carbonera	--	--	--
Eastern and Southern	La Sal - San Juan	Grand San Juan	[illegible]	--	--	--	--
Eastern and Southern	[illegible]	[illegible] [illegible]	[illegible]	[illegible] [illegible]	--	--	--
Eastern and Southern	Coalville	Summit	[illegible]	[illegible]	--	--	--
Eastern and Southern	[illegible]	[illegible]	[illegible]	--	--	--	--
Eastern and Southern	[illegible]	[illegible]	[illegible]	--	--	--	--
Eastern and Southern	Lost Creek	Morgan	[illegible]	--	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.
[b] 1 = strip mine; 2 = deep mine; 3 = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Washington							
Northern	Whatcom	Whatcom	23	Bellingham #1	--	--	--
				Blue Canyon			
				Lake Whatcom			
				Bellingham #2			
				Unnamed			
				Unnamed			
				Unnamed			
				Unnamed			
Northern	Skagit	Skagit	23	Cokedale	--	--	--
Issaquah - Grand Ridge	Newcastle - Grand Ridge	King	23	#2	--	--	--
				#3			
				#4			
				Bagley			
				May Creek			
				Muldoon			
				Dolly Varden			
				Jones			
Issaquah - Grand Ridge	Cedar Mountain	King	23	Cavanaugh #2	--	--	--
				Jones			
				Discovery			
				Ryan #1			
				New Lake Youngs #2			
				Cedar Mountain #2			
				Cedar Mountain #1			

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	County	District	Seam[a]	Active Mine	Type[b]	Company
Washington (cont.)							
Issaquah - Grand Ridge	Renton	King	21	#1 #2 #3 Springbrook Sunbeam Newenham Springhaven Sevtor	--	--	--
Issaquah - Grand Ridge	Tiger Mountain	King	21	#1 #3	--	--	--
Issaquah - Grand Ridge	Niblock	King	21	#3 #4 #5	--	--	--
Issaquah - Grand Ridge	Taylor	King	21	#2 #3 #4 #5 #6	--	--	--
Green River	Green River	King	21	Unnamed McKay Gem (1) Rogers #3 Ravensdale #3 Ravensdale #4 Ravensdale #5	(1)(2) Rogers Mine	D	Palmer Coking Coal Co.

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seam[a]	Active Mine	Type[b]	Company
Washington (cont.)							
Green River (cont.)				Ravensdale #9			
				Fulton			
				(2) Franklin #12			
				Dale #4			
				Harris			
				Nanny #6			
				Big Dean			
				Blayne #2			
				Blayne #3			
Wilkeson - Carbonado	Wilkeson - Carbonado	Pierce	21	Wilkeson #1	--	--	--
				" #2			
				" #3			
				" #4			
				" #5			
				" #7			
				Carbonado #5			
				Carbonado #8			
				Morgan #7			
				Big Ben			
				Spiketon #6			
				" #7			
				" #8			
				" #10			
				" #11			
				" #12			

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State-Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Washington (cont.)							
Wilkeson - Carbonado (cont.)				Melmont #1	Melmont #[illegible]		
				" #2	Melmont #[illegible]		
				" #2 1/2	Melmont #[illegible]		
				" #3			
Fairfax-Ashford	Fairfax-Ashford	Pierce	23	Montezuma #1	--	--	--
				" #2			
				" #3			
				" #4			
				" #5			
				" #6			
				Blacksmith			
				McNeill			
				Unnamed			
				Unnamed			
				Unnamed			
				Nisqually			
Centralia-Chehalis	Centralia-Chehalis	Lewis Thurston	23	Tono #1	(3) (4) Centralia	S	Washington Irrigation and Development Co.
				Upper Thompson			
				Golden Glow			
				Mendota			
				Lucas Creek			
				Lower Thompson			
				Big Dirty			
				Little Dirty			
				(3) Smith			

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.
[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Washington (cont.)							
Centralia-Chehalis (cont.)				Penitentiary			
				D & F			
				Tono #1			
				Black Bear			
				(4) Big			
Morton	Morton	Lewis	23	Unnamed	--	--	--
				Unnamed			
				Unnamed			
				Unnamed			
				#2			
				#3			
				#4			
				Unnamed			
				Unnamed			
				Unnamed			
				Unnamed			
				Unnamed			
Eastern Lewis County	Eastern Lewis County	Lewis	23	--	--	--	--
Kelso Castle Rock	Kelso Castle Rock	Cowlitz Lewis	23	Leavell	--	--	--
				Cherry Creek			
				Unnamed			
				Unnamed			
				Walker			
				Silver Creek			
				Unnamed			

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Washington (cont.)							
Belas Castle Rock (cont.)				Schuff Cedar Creek #1 Unnamed			
Roslyn	Roslyn	Kittitas	23	Big Dirty #1 Big Dirty #1 Roslyn #5 Plant #6 Green #7 Wright #8 Unnamed	--	--	--
Taneum-Manastash	Taneum-Manastash	Kittitas	23	--	--	--	--
Wyoming							
Powder River Basin	Dry Cheyenne/Glenrock	Converse	19	Badger (1) School F	(1) Dave Johnston Mine	S,C	Pacific Power & Light Co.
Powder River Basin	Spotted Horse	Campbell Sheridan	19	Canyon Felix Smith	--	--	--
Powder River Basin	Sheridan	Sheridan	19	Carney (2) Monarch Kleenburn (3) Armstrong	(2)(3) Big Horn Mine	S	Big Horn Coal Co.
Powder River Basin	Sussex	Johnson	19	Lower Upper	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Wyoming (cont.)							
Powder River Basin	Gillette	Converse	19	D E F	--	--	--
Powder River Basin	Powder River	Campbell	19	(4) Wyodak Arvada Felix Lower Pin (5) Roland Smith	(4)(5) Belle-Ayr Mine (5) Wyodak Mine	S S	Amax Coal Co. Wyodak Resources Development Corp.
Powder River Basin	Buffalo	Johnson	19	Healy Dry Creek Ucross	--	--	--
Powder River Basin	Barber	Johnson	19	--	--	--	--
Powder River Basin	Lost Spring	Converse	19	B D E	--	--	--
Green River	Little Snake River	Carbon	19	B C	--	--	--
Green River	Great Divide Basin - Red Desert	Sweetwater Carbon	19	Battle #2 Battle #1 Creston #2 Creston #1 Hadsell #2 Sourdough - Monument - Tierney	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	[illegible]	Seams[a]	Active Mine	Type[b]	Company
Wyoming (cont.)							
Green River (cont.)				Jim Bridger			
				Latham #1			
				Latham #4			
				[illegible]			
Green River	Rock Springs	Sweetwater	19	(6) Rock Springs #7	(7) Rainbow #7	S	Gunn-Quealy Coal
				(7) Rock Springs #11	(6) Rainbow #8	[illegible]	Gunn-Quealy Coal
Hanna Field [illegible]	Hanna Field	Carbon	19	(8) #25	(8) Seminoe #1 Mine	S	Arch Minerals Corp.
				(3) Hanna #2	(12)(13) Rosebud Mine	S	Rosebud Coal Sales Co.
				(10) Brooks	Rimrock No. 2	S	Resources Exploration & Mining Inc.
				(11) #65	(10) [illegible] Strip Mine	S	Energy Development, Inc.
				(12) #80	(11) Vanguard No. 1	S	Energy Development, Inc.
				(13) #82	Rimrock No. 1	S	Resources Exploration & Mining Inc.
				#50	(8) Seminoe #2 Mine	S	Arch Minerals Corp.
Hams Fork	Kemmerer	Lincoln	19	(14) Adaville #1	(14) Elkol Mine	S	Kemmerer Coal Co.
				#11	(14) Sorenson Mine	S	Kemmerer Coal Co.
				#7			
Big Horn Basin	Gebo	Hot Springs	19	Unnamed	--	--	--
Big Horn Basin	Grass Creek	Hot Springs	19	Unnamed	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

Table C-3 (continued). COALFIELD IDENTIFICATION

State/Region	Field	Counties	District	Seams[a]	Active Mine	Type[b]	Company
Wyoming (cont.)							
Miscellaneous	Goshen Hole	Goshen	19	--	--	--	--
Miscellaneous	Rock Creek	Albany	19	--	--	--	--
Miscellaneous	Jackson Hole	Teton	19	--	--	--	--
Miscellaneous	Wind River Basin	Fremont	19	--	--	--	--
Miscellaneous	Black Hills Region	Crook	19	--	--	--	--

[a] Numbers in parentheses refer to known seams actively mined in corresponding mines.

[b] S = strip mine; D = deep mine; C = captive mine

APPENDIX D

CURRENT UTILIZATION OF WESTERN COALS
BY USER TYPE

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Table D-1 is a compilation of all known U.S. plants burning coal or contemplating burning coal derived from states included in this study. All data presented in Table D-1 originate from the 1973 Keystone Coal Industry Manual published by McGraw-Hill.[1]

A total of 97 electric utilities burned western coal in 1972. Thirty-eight of these plants are located outside of the western producing districts. Thirteen industrial plants burned western coal in 1972. Two of these plants are located outside of the western producing districts.

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Table D-1. COAL BURNING PLANTS-ELECTRIC UTILITY[1]

State	Utility Company	City	Plant	Tonnage Utilized & Source of Coal
Arizona	Arizona Public Service Co.	Joseph City	Cholla	348,000 T. (1972) N.M.
	Public Service Co. of N. Mex.	Page	San Juan	Under Construction
	Salt River Project	Phoenix	Navajo	Under Construction
Colorado	Colorado Springs, Dept. Public Utilities	Colorado Sp.	Drake Steam	100,000 T. (1972) ?
	Colorado Ute Elec. Assn.	Nucla	Nucla	75,000 T (1972) Colo.
		Hayden	Hayden	[illegible] T. (1972) Colo.
	Fort Collins Light & Power	Ft. Collins	Light & Power Dept.	5,400 T. (1972) Colo.
	Public Service Co. of Colo.	Boulder	Valmont Steam	210,000 T. (1971) ?
		Denver	Arapahoe	285,000 T. (1971) Colo., Wyo.
		Alamosa	Alamosa	1,300 T. (1971) ?
		Denver	Cherokee	[illegible] T. (1971) ?
		Cameo	Cameo Steam	130,000 T. (1971) Colo.
			Comanche	Under Construction
	Southern Colorado Power	Pueblo	Pueblo	2,400 T. (1972) ?
	Div. Central Telephone & Utilities Corp.	Canon City	W. N. Clark City	93,000 T. (1972) Colo.
	Walsenburg Utilities	Walsenburg	Walsen	13,000 T. (1971) ?
	Western Colorado Power Co.	Montrose	Jim Bullock	[illegible],000 T. (1971) Colo.
		Durango	Durango	2,000 T. (1971) Colo.
Illinois	Commonwealth Edison Co.	Chicago	Fisk	720,000 T. (1972) Mont., Wyo.
		Chicago	Crawford	930,000 T. (1972) Mont., Wyo.
		Waukegan	Waukegan #1	2,131,000 T. (1972) Ill., Ky., W., Wyo.
		Joliet	Joliet	4,819,000 T. (1972) Ill., Mont.
		Pekin	Powerton	1,114,000 T. (1972) Mont., Ill.
		Dixon	Dixon	291,000 T. (1972) Ill., Ind., Ky., W., Wyo.
Indiana	Commonwealth Edison Co. of Indiana	Hammond	State Line	[illegible] T. (1972) Ill., Ind., Mont., Wyo.
Iowa	Iowa Electric Light & Power	Iowa Falls	Iowa Falls	[illegible] T. (1972) ?
		Marshalltown	Sutherland	193,000 T. (1972) ?
	Iowa Power and Light Co.	Council Bluffs	Council Bluffs	278,000 T. (1972) Wyo.
		Des Moines	Des Moines No. 2	[illegible] T. (1972) Iowa, [illegible]
	Iowa Public Service Co.	Eagle Grove	Eagle Grove	[illegible] T. (1972) ?
		Salix	George Neal	[illegible] T. (1972) Wyo.

Table D-1 (continued). COAL BURNING PLANTS-ELECTRIC UTILITY[1]

State	Utility Company	City	Plant	Tonnage Utilized & Source of Coal
Iowa	Iowa Public Service Co.	Storm Lake	Hawkeye	8,880 T. (1972) ?
Minnesota	Hibbing Public Utilities Comm.	Hibbing	Hibbing	100,000 T. (1972) Mont.
	Minnesota Power & Light Co.	Duluth	M.L. Hibbard S.E.	361,000 T. (1972) W. Va., Mont.
		Aurora	Aurora S.E.	352,000 T. (1972) Mont.
		Cohasset	Clay Boswell	597,090 T. (1972) Mont.
	Moorhead Public Service Dept.	Moorhead	Moorhead	3,636 T. (1972) N.D.
	Otter Tail Power Co.	Fergus Falls	Hoot Lake	700,000 T. (1972) N.D.
		Ortonville	Ortonville	109,000 T. (1972) N.D.
	Northern States Power Co.	Granite Falls	Minnesota Valley	96,000 T. (1972) Ill., Kans., Ky., N.D.
		Mankato	Wilmarth	30,000 T. (1972) N.D., Mont.
		Minneapolis	Riverside	942,000 T. (1972) Ill., Ky., W., Mont.
		St. Paul	High Bridge	500,000 T. (1972) Ill., Ky. (W), Mont., Okla.
		Red Wing	Red Wing	32,000 T. (1972) N.D.
		Winona	Winona	30,000 T. (1972) Ill., N.D.
Missouri	Kansas City Power & Light Co.	Kansas City	Hawthorn	1,025,600 T. (1972) Mo., Kans., Okla., Wyo.
Montana	Montana-Dakota Utilities Co.	Sidney	Lewis & Clark	320,000 T. (1972) ?
	Montana Power Co.	Billings	J.E. Corette	449,000 T. (1972) ?
		Colstrip	Colstrip	Under construction
Nebraska	Fremont Dept. of Utilities	Fremont	Fremont	35,000 T. (1972) Kans., Wyo.
	Nebraska Public Power Dist.	Hallam	Sheldon	251,800 T. (1972) ?
		Bellevue	Kramer	146,000 T. (1972) Kans., Colo.
	Lincoln Electric System	Lincoln	Lincoln	400 T. (1971) ?
	Omaha Public Power Dist.	Omaha	N. Omaha	743,110 T. (1972) Kans., Wyo., Mo., Okla.
		Omaha	Jones Street	29,300 T. (1972) ?
Nevada	Nevada Power Co.	Moapa	Reid Gardner	600,000 T. (1971) Utah
	Southern California Edison	Laughlin	Mohave	2,910,000 T. (1972) Ariz.
New Mexico	Arizona Public Service Co.	Fruitland	Four Corners	6,893,000 T. (1972) N.M.
	Public Service Co. of N. Mex.	Fruitland	San Juan	Under construction
	Raton Public Service Co.	Raton	Raton	24,000 T. (1971) N. Mex.

Table D-1 (continued). COAL BURNING PLANTS-ELECTRIC UTILITY[1]

State	Utility Company	City	Plant	Tonnage Utilized & Source of Coal
N. Dakota	Basin Electric Power Coop.	Stanton	Leland Olds	1,316,000 T. (1972) ?
	Central Power Elec. Coop.	Velva	Wm. J. Neal	205,000 T. (1972) ?
	Minnkota Power Coop.	Center	Milton R. Young	1,420,000 T. (1972) ?
		Grand Forks	Franklin P. Wood	4,000 T. (1972) ?
	Montana-Dakota Utilities Co.	Beulah	Beulah	102,000 T. (1972) N.D.
		Mandan	R.M. Heskett	570,000 T. (1972) N.D.
	Northern States Power Co.	Minot	Bison	41,000 T. (1972) N.D.
	Otter Tail Power Co.	Devils Lake	Devils Lake	67,000 T. (1972) N.D
		Jamestown	Jamestown	57,000 T. (1972) N.D.
		Wahpeton	Kidder	20,000 T. (1972) N.D.
	United Power Association	Stanton	Stanton	862,000 T. (1972) ?
	Valley City Electric & Water Works	Valley City	Valley City	18,979 T. (1972) Beulah Dist. of N.D.
S. Dakota	Black Hills Power & Light Co.	Lead	Kirk	104,000 T. (1971) Wyo.
		Rapid City	Ben French	103,000 T. (1971) Wyo.
	Montana-Dakota Utilities Co.	Mobridge	Mobridge	15,000 T. (1972) N.D.
	Northern States Power Co.	Sioux Falls	Lawrence	50,000 T. (1972) Mont., Okla., Kans.
	Northwestern Public Service	Aberdeen	Aberdeen	20,000 T. (1972) Wyo.
		Mitchell	Mitchell	20,000 T. (1972) Wyo.
Utah	California Pacific Utilities	Cedar City	Cedar Stream	9,930 T. (1971) Utah
	Provo Water and Power Dept.	Provo	Provo City	11,343 T. (1972) Utah
	Utah Power & Light Co.	Salt Lake C.	Gadsby	32,000 T. (1971) Utah
		Castle Gate	Carbon Steam	371,000 T. (1971) Utah
		Orem	Hale	4,000 T. (1971) Utah
		Huntington	Huntington Canyon	Under construction
Washington	Pacific Power & Light Co. & Washington Water Power Co.	Centralia	Centralia	2,003,000 T. (1972) Wash.
Wisconsin	Dairyland Power Cooperative	Alma	Alma	565,000 T. (1971) Ill., Ky., W., Ark., Mont.
		Genoa	Genoa	725,000 T. (1971) Ill., Ky., W., Ark., Wyo.
	Northern States Power Co.	La Crosse	French Island	12,000 T. (1972) N.D.
	Wisconsin Electric Power Co.	Oak Creek	Oak Creek	3,362,000 T. (1972) Ill., Ky., W., Ind., Wyo.

Table D-1 (continued). COAL BURNING PLANTS-ELECTRIC UTILITY[1]

State	Utility Company	City	Plant	Annual Utilization & Source of Coal
Wyoming	Black Hills Power & Light Co.	Osage Wyodak	Osage Neil Simpson Unassigned	[illegible] T. (1971) Wyo. [illegible] T. (1971) Wyo. Under construction
	Montana-Dakota Utilities Co.	Sheridan	Acme	95,000 T. (1971) Wyo. Under construction
	Pacific Power & Light Co. Utah Power & Light Co.	Kemmerer Glenrock Rock Springs	Naughton Dave Johnston Jim Bridger	1,4[illegible] T. (1971) [illegible] [illegible] T. (1971) [illegible] Under construction

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[1] pp. 345-391.

Table D-2. COAL BURNING PLANTS-INDUSTRIAL[1]

State	Company	City	Plant	Tonnage Utilized & Source of Coal
Colorado	American Crystal Sugar Co.	Denver	--	415,000 T. (1971) ?
	Great Western Sugar Co.	Denver	--	404,091 T. (1971) ?
	Ideal Cement Co.	Ft. Collins	Boettcher	19,000 T. (1972) ?
Idaho	Amalgamated Sugar Co.	Twin Falls	Twin Falls	40,000 T. (1972) Utah
		Nampa	Nampa	67,000 (1972) Utah, Wyo.
		Rupert	Mini-Cassia	51,000 T. (1972) Utah, Wyo.
	Bunker Hill Co.	Kellogg	Lead Smelter	36,000 T. (1971) Utah, Wyo., Brit. Col.
	Monsanto Co.	Soda Springs	Soda Springs	20,000 T. (1972) Wyo.
Illinois	General Motors Corp.	La Grange	Electro-Motive Div.	55,000 T. (1971) Ky., Utah
Iowa	Clinton Corn Processing Co.	Clinton	Clinton	332,000 T. (1971) Ill., Ky., Wyo.
Oregon	Amalgamated Sugar Co.	Nyssa	Nyssa	53,000 T. (1971) Utah, Wyo.
Utah	Marblehead Lime Co.	Grantsville	Delle	30,000 T. (1972) Utah
	Ideal Cement Co.	Morgan	Devil's Slide	14,000 T. (1972) ?

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[1] pp. 304-335.

APPENDIX E

COAL PRICES F.O.B. MINE
BY COUNTY FOR 1972

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Table E-1. PRODUCTION, SHIPMENTS, AND VALUE AT BITUMINOUS COAL AND LIGNITE MINES, IN 1972, BY STATE AND COUNTY[22]
(thousand short tons)

State and county	Production: Underground: Number of mines	Production: Underground: Quantity	Production: Strip: Number of mines	Production: Strip: Quantity	Production: Auger: Number of mines	Production: Auger: Quantity	Shipments: Rail or water	Shipments: Truck	Shipments: Mine-mouth generating plants	Shipments: All other	Shipments: Total	Average value per ton
Arizona:												
Navajo	-	-	1	[illegible]	-	-	-	-	-	[illegible]	[illegible]	[illegible]
Colorado:												
Delta	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Fremont	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Garfield	[illegible]	[illegible]	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Gunnison	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Huerfano	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
La Plata	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Las Animas	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Mesa	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Moffat	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Montrose	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pitkin	[illegible]	[illegible]	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Rio Blanco	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Routt	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Weld	[illegible]	[illegible]	[illegible]	[illegible]	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total or average[2]	77	[illegible]	8	[illegible]	-	-	8,771	712	587	2	9,580	6.69
Montana (bituminous):												
Big Horn	-	-	1	772	-	-	772	-	-	-	772	[illegible]
Musselshell	3	17	[illegible]	[illegible]	-	-	-	[illegible]	-	-	[illegible]	[illegible]
Rosebud	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
Total or average[2]	3	17	4	[illegible]	-	-	[illegible]	26	-	-	[illegible]	2.01
Montana (lignite):												
Powder River	-	-	[illegible]	[illegible]	-	-	-	[illegible]	-	-	[illegible]	[illegible]
Richland	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
Total or average[2]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
Total or average Montana[2]	3	17	6	[illegible]	-	-	[illegible]	28	-	-	[illegible]	[illegible]
New Mexico:												
Colfax	1	[illegible]	[illegible]	17	-	-	[illegible]	-	-	-	[illegible]	[illegible]
McKinley	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
San Juan	-	-	[illegible]	[illegible]	-	-	-	-	[illegible]	-	[illegible]	[illegible]
Total or average[2]	1	[illegible]	4	[illegible]	-	-	1,427	5	[illegible]	-	[illegible]	[illegible]
North Dakota (lignite):												
Adams	-	-	[illegible]	[illegible]	-	-	-	[illegible]	-	-	[illegible]	[illegible]
Bowman	-	-	[illegible]	[illegible]	-	-	[illegible]	-	-	[illegible]	[illegible]	[illegible]
Burke	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
Grant	-	-	[illegible]	[illegible]	-	-	-	-	-	-	[illegible]	[illegible]
McLean	-	-	[illegible]	[illegible]	-	-	-	[illegible]	-	-	[illegible]	[illegible]
Mercer	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
Oliver	-	-	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]
Stark	-	-	[illegible]	[illegible]	-	-	-	-	[illegible]	-	[illegible]	[illegible]
Ward	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
Williams	-	-	[illegible]	[illegible]	-	-	[illegible]	-	[illegible]	-	[illegible]	[illegible]
Total or average[2]	-	-	16	[illegible]	-	-	[illegible]	[illegible]	1,157	68	[illegible]	[illegible]

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Table F-1 (continued). PRODUCTION, SHIPMENTS, AND VALUE AT BITUMINOUS COAL AND LIGNITE MINES, IN 1972, BY STATE AND COUNTY[22]
(thousand short tons)

State and county	Production						Shipments					Average value per ton[4]
	Underground		Strip		Auger		Rail or water[1]	Truck	Mine-mouth generating plants	All other[2]	Total[3]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Utah:												
Carbon	11	[illegible]	1	[illegible]	-	-	[illegible]	296	-	2	4,044	[illegible]
Emery	8	[illegible]	-	-	-	-	[illegible]	484	-	-	1,589	[illegible]
Sevier	1	[illegible]	-	-	-	-	96	138	-	-	[illegible]	[illegible]
Summit	1	[illegible]	-	-	-	-	-	[illegible]	-	-	5	[illegible]
Total or average[3]	[illegible]	[illegible]	1	17	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]
Washington:												
King	1	[illegible]	-	-	-	-	-	79	-	-	79	[illegible]
Lewis	-	-	2	[illegible]	-	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]
Total or average[3]	1	[illegible]	2	[illegible]	-	-	-	98	[illegible]	-	[illegible]	[illegible]
Wyoming:												
Campbell	-	-	[illegible]	[illegible]	-	-	[illegible]	17	[illegible]	1	[illegible]	*
Carbon	1	195	6	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]
Converse	-	-	[illegible]	[illegible]	-	-	-	-	[illegible]	-	[illegible]	[illegible]
Hot Springs	[illegible]	[illegible]	-	-	-	-	*	6	-	-	[illegible]	[illegible]
Lincoln	-	-	[illegible]	[illegible]	-	-	[illegible]	-	[illegible]	[illegible]	[illegible]	*
Sheridan	-	-	[illegible]	[illegible]	-	-	[illegible]	[illegible]	-	-	[illegible]	*
Sweetwater	2	[illegible]	1	[illegible]	-	-	[illegible]	1	-	[illegible]	[illegible]	[illegible]
Total or average[3]	[illegible]	[illegible]	11	[illegible]	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total or average for United States	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Withheld to avoid disclosing individual company data.

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by truck to railroad sidings, and hauled by truck to waterways.

[2] Includes coal used at mine for power and heat, made into beehive coke at mine, [illegible] to mine employees, used for all other purposes at mine and shipped by slurry pipeline to Arizona.

[3] Data may not add to totals shown because of independent rounding.

[4] Value received or charged for coal f.o.b. mine. Includes a value for coal not sold but used by producers, such as mine fuel and coal [illegible], as estimated by producers at average prices that might have been received if such coal had been sold commercially.

[5] Less than 500 tons.

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[22] pp. [illegible].

APPENDIX F

FEDERAL AND STATE SURFACE MINING LEGISLATION

A summary of regulations concerning surface mining in force as of 1972 is included in this Appendix. The regulations for federally owned lands are shown in Table F-1. The state laws are summarized in Table F-2. States possessing no regulations per se in 1972 were Arizona, New Mexico, Oregon, South Dakota, and Utah. Normally states and areas not having specific laws fall under Indian agreements or federal jurisdiction. The continuous flux of surface mining legislation is realized and as such more current legislation should be investigated on a case by case basis.

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Table F-1. A SUMMARY OF THE REGULATIONS GOVERNING SURFACE MINING ON LANDS UNDER THE JURISDICTION OF THE U.S. GOVERNMENT[a,2]

Law and date	Code of Federal Regulations. Title 43, Part 23, January 18, 1969, and Title 43, Part 3501.1-4(b) (1), June 13, 1970. The Mineral Leasing Act of February 25, 1920, as amended and supplemented (30 U.S.C. 181-287), the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351-359), and the Materials Act of July 31, 1947, as amended (30 U.S.C. 601-604).
Minerals subject to	All leasable or salable minerals owned by the U.S. Government.
Regulating agency	The District Manager, Bureau of Land Management, in cooperation with the Federal agency having jurisdiction over the land, if appropriate, and in consultation with the Regional Mining Supervisor, U.S. Geological Survey, and, if necessary, in consultation with the Federal Water Quality Administration, and in consultation with the private owners of the surface rights, if appropriate.
Permit requirements:	
Basic fee	Each application for permit, lease, or license must be accompanied by a service charge of $10.
Additional	A minimum annual rental of 25 cents per acre for the first year, 50 cents per acre for the second through the fifth years, and $1 per acre thereafter. Each permit may include up to 5,120 acres. An individual or corporation may hold up to 46,080 acres in permits or leases.
Penalty for failure to comply	Failure of an operator to comply with the terms of a permit or lease shall be cause for the Mining Supervisor or District Manager to take action to cancel the permit or lease and forfeiture of bond.

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Table F-1 (continued). A SUMMARY OF THE REGULATIONS GOVERNING SURFACE MINING ON LANDS UNDER THE JURISDICTION OF THE U.S. GOVERNMENT

Bond requirements:	
Minimum	$2,000. In lieu of a performance bond, the operator may deposit cash or negotiable bonds of the U.S. Government.
Additional	The amount of the bond shall be sufficient to satisfy the reclamation requirements of an approved mining plan.
Reclamation requirements:	
Plan required	Yes, to be filed with the Mining Supervisor and outlining the mining operation and the measures to be taken to protect the environment and eliminate any hazards to health and safety.
Backfilling and grading	The mining plan shall show the proposed methods and timing of grading and backfilling of the areas affected by the mining operation. The mining plan is subject to review and approval by the Mining Supervisor or the District Manager. Mutual acceptance of a mining plan is binding on the part of the operator. The mining plan may be amended if warranted by unforeseen circumstances.
Replanting	If stipulated in the permit, lease, or contract, the mining plan shall show the method of preparing and fertilizing the soil, and the types and mixtures of grasses, shrubs or trees, and the amount, per acre.
Substitution of lands permitted	No.
Mining and reclamation reports	Within 30 days of the end of each calendar year, or within 30 days of the cessation of operations, the operator shall file with the Mining Supervisor a description of the operation, including the area affected

Table F-1 (continued). A SUMMARY OF THE REGULATIONS GOVERNING SURFACE MINING ON LANDS UNDER THE JURISDICTION OF THE U.S. GOVERNMENT

	and the area reclaimed, the method of reclamation and results, and the reclamation yet to be done.
Penalty for failure to reclaim:	
Bond forfeiture	Yes, for failure to comply with the surface protection and reclamation aspects of an approved mining plan.
Denial of new permit	Yes, for forfeiture of bond unless the disturbed land has been subsequently reclaimed without cost to the Federal Government.

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[a] Applies principally to Alaska, Arizona, California, Idaho, Montana, Nevada, New Mexico, North Dakota, Utah, Washington, and Wyoming.

Table F-2. SUMMARY OF THE LAWS REGULATING STRIP MINING IN THE UNITED STATES, BY STATES[2]

Arizona	
Law and date	None.
Regulating agency	Regulated by Federal law applying to the Navajo and Hopi Indian Reservations. Individual agreements are made between the coal producers and the tribe concerned.
Colorado	
Law and date	Colorado Open Cut Land Reclamation Act of 1969.
Minerals subject to	Coal.
Regulating agency	Colorado Department of Natural Resources.
License requirements:	
Basic fee	$50.
Additional	None.
Penalty for failure to comply	No legal obligation other than that provided in the contract agreement.
Bond requirements:	
Minimum	$2,500 for mining on Indian lands or the public domain - Federal requirement.
Additional	Not to exceed $100 per acre of disturbed land.
Reclamation requirements:	
Plan	Only after mining is completed. Maps are required.
Backfilling and grading	Exposed face of seam must be covered by at least 2 feet of earth or spoil or by at least 2 feet of water. Strike off ridges to minimum top width of 10 feet; strike off peaks to a minimum of 15 feet; impound water. Grade to a rolling topography, operator shall provide access roads.
Replanting	Operator may reclaim land for forest, range, crop, or other use in cooperation with the state.

Table F-2 (continued). SUMMARY OF THE LAWS REGULATING STRIP MINING IN THE UNITED STATES, BY STATES

Montana	
Law and date	Chapter 245, 1967 Session Laws
Minerals subject to	Coal.
Regulating agency	Montana Bureau of Mines and Geology
License requirements:	
Basic fee	$0.05 per ton tax on excess of 50,000 tons.
Additional	None.
Penalty for failure to comply	A contract agreement prevails between the State and the operator.
Bond requirements:	
Minimum	None.
Additional	None.
Reclamation requirements	
Backfilling and grading	Reclamation costs are extended as credit toward paying the coal mines license tax.
New Mexico	
Law and date	None.
Minerals subject to	On Indian lands, mining is in accordance with the individual agreement between the operator and the Indians.
North Dakota	
Law and date	Chapter 38-01 through 14. North Dakota Century Code. Effective 1919, as revised. Reclamation of Strip Mined Lands, Chapter 38-14, January 1, 1970, and amended July 1, 1971.
Minerals subject to	Any mineral where the overburden exceeds 10 feet in depth.
Regulating agency	State Mine Inspector (mining): Public Service Commission (reclamation)
License requirements	$5 annually for 100 tons or less; $15 for 101 to 1,000 tons; $45 for 1,001 to 5,000 tons; $65 for 5,001

Table F-2 (continued). SUMMARY OF THE LAWS REGULATING STRIP MINING IN THE UNITED STATES, BY STATES

North Dakota (continued)	
	to 10,000 tons; $85 for 10,001 to 20,000 tons; $125 for 20,001 to 50,000 tons; $200 for 50,001 to 200,000 tons; $300 for more than 200,000 tons.
Permit requirements	Permit term is for 3 years. For 10 acres or less, $25 and an amount equal to $7.50 times the number of acres affected. For 11 to 50 acres, $100 and an amount equal to $3.50 times the number of acres. For over 50 acres, $275 and an amount equal to $2.50 times the number of acres. Permit applications shall describe the area and the estimated acreage to be affected in the following 3 years. Permits may be amended. Extensions may be granted on an annual basis.
Penalty for failure to comply	Willful neglect or violation of the regulations is a misdemeanor punishable by fine or imprisonment, or both, to the extent of $500 or 6 months in jail.
Bond requirements	$200 per acre of land mined, or fraction thereof, where the overburden exceeds 10 feet.
Reclamation requirements:	
Plan	Required. A plan and map shall be submitted not later than the first day of December following date of the mining permit. The plan and approval thereof are subject to the advice of other agencies and persons having experience in reclamation. The plan must designate the intended future use of the disturbed area. The landowner is granted the option of determining the method of reclamation.

Table F-2 (continued). SUMMARY OF THE LAWS REGULATING STRIP MINING IN THE UNITED STATES, BY STATES

North Dakota (continued)	
Backfilling and grading	Depends on the proposed future use. For crops and hay, peaks and ridges graded and valleys filled to extent necessary to enable the traverse of farm machinery. For pasture, peaks and ridges must be struck off to minimum width of 35 feet. For forest planting, peaks and ridges are to be struck off to a minimum width of 35 feet. Negotiable access roads must be provided. Earth dams must be provided to prevent runoff except that lakes and ponds shall not interfere with mining. Land within 660 feet of, and visible from any public road, building, or cemetery must be graded to a rolling topography with slopes of not more than 20 percent grade.
Replanting	Bond or other surety may be forfeited for failure to comply with the reclamation plan. However, two plantings or seedings relieve the miner from further obligations, regardless of success or failure of the planting efforts.
Mining and reclamation reports	The operator shall submit by September 1 of each year of the permit term, a map showing pit location with a description of the land affected.
Substitution of lands	Not permitted.
Penalty for failure to reclaim:	
Bond forfeiture	Bond is forfeited. No new permits will be issued and all other mining operations in North Dakota must cease in 30 days. The Commission has the authority to reclaim any affected land on which a bond has been forfeited.

Table F-2 (continued). SUMMARY OF THE LAWS REGULATING STRIP MINING IN THE UNITED STATES, BY STATES

Utah	
Law and date	None.
Regulating agency	Regulated by Federal laws, enforced by the Industrial Commission of Utah and the Utah State Division of Health.
Washington	
Law and date	Title 76, RCW, January 1, 1971
Minerals subject to	All in which more than 10,000 tons are produced in 1 year, or which newly disturbs more than 2 acres of land in 1 year.
Mining and reclamation reports	Operator is required to file an activities report within 30 days after the completion of mining, or within 30 days of the anniversary of the operating permit, whichever is earlier.
Penalty for failure to reclaim:	
Bond forfeiture	Bond forfeited if reclamation is not completed within 2 years of the completion of mining. New permit denied for failure to complete the required reclamation work.
Regulating agency	Board of Natural Resources.
License requirements:	
Basic fee	$25 per year per separate mining operation.
Additional	$5 per acre for the excess over 10 acres disturbed during the previous year.
Penalty for failure to comply	Operating without a permit is a gross misdemeanor. Each day of such operation constitutes a separate violation.
Bond requirements:	
Minimum	Not less than $100 per acre. Cash, savings, or other suitable securities may be substituted in lieu of bond.

Table F-2 (continued). SUMMARY OF THE LAWS REGULATING STRIP MINING IN THE UNITED STATES, BY STATES

Washington (continued)	
Additional	The estimated cost of reclaiming that area to be disturbed during the next 12 months plus any area for which a permit has been issued and the reclamation not completed. The amount shall not exceed $1,000 per acre or fraction thereof.
Reclamation requirements:	
Plan	Required. It should state the proposed subsequent use of the land, method of restoration, revegetation, water control, and the prevention of hazards.
Backfilling and grading	Spoil banks shall be reduced to a gently rolling topography. Banks of pits shall be sloped. Quarry walls shall be stepped or backfilled to eliminate any hazards. Drainage shall be provided for surface waters and all acid-forming material shall be covered by clean fill.
Replanting	Vegetative cover is required commesurate with the future use of the restored land.
Wyoming	
Law and date	Open Cut Land Reclamation Act, May 23, 1969.
Minerals subject to	All underlying sufficient overburden to require disturbing the cover.
Regulating agency	Commissioner of Public Lands.
License Requirements:	
Basic fee	$50.
Additional	None.
Penalty for failure to comply	$1,000. Each operating day is considered a separate offense.
Bond requirements:	
Minimum	Depending on the acreage disturbed and that reclaimed in the past year, the amount of bond may be set by the

Table F-2 (continued). SUMMARY OF THE LAWS
REGULATING STRIP MINING IN THE UNITED STATES, BY STATES

Wyoming (continued)	
	Commissioner in an amount sufficient to reclaim the land. Cash or other security may be posted in lieu of bond.
Reclamation requirements:	
Plan	Reclamation plan is required, with mine map.
Backfilling and grading	Exposed seams may be covered to a depth of at least 2 feet. Peaks and ridges must be reduced to a rolling topography. Dangerous effluent must be impounded.
Replanting	Replanting is required in conformance with the recommendations by the Soil Conservation Service and compatible with the surrounding area.
Mining and reclamation reports	Must be filed annually, and may be followed by inspection.
Substitution of lands	May be permitted at the discretion of the regulating agency.
Penalty for failure to reclaim	Bond will not be released until reclamation is completed. New permit may be denied. On Federal Land, the Bureau of Land Management may permit the operator the option of complying with the State regulations rather than with those stipulated by the U.S. Government.

APPENDIX G

COAL ANALYSES BY COUNTY AND MINE

The data presented in this appendix represent a compilation of available state and federal reports. Data is presented by state with the furthest subdivision being the coalfield, town or mine from which the coal originated. The data is principally transcribed "as is" and nonalphabetized from the various sources with the objective being to present as much data as possible in the shortest amount of time.

The data in Table G-1 is arranged principally in the format utilized in federal government tipple analyses. All percentage figures are on % by weight basis. Moisture % is on an "as received" basis. Remaining proximate and ultimate analysis data are for dry coal. Calorific value is listed as either Btu per pound of "as received" coal or Btu per pound of dry coal. Ash softening temperature, more commonly called the fusion temperature of the ash, is given wherever possible. This temperature is related to that at which the fuel ash shows a greatly accelerated tendency to mass together and stick in large quantities to heat absorbing surfaces. It was unclear from the reports reviewed whether or not the fusion temperature was reported under reducing or oxidizing atmosphere conditions. The atmosphere under which the test is conducted can affect the magnitude of the temperature reading. It is assumed that all ash softening temperatures reported in this appendix are recorded under reducing conditions as this is common practice. Free swelling index indicates closely the coking characteristics of bituminous coal when burned in fuel beds. Those analyses reporting this figure tend to indicate that the coal is coking. Hardgrove grindability index is reported wherever possible to indicate the relative grindability or ease of pulverizing coals in comparison with a coal chosen as having a grindability of 100.

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The following is a list of bibliography references used to compile the above information which correspond numerically to those shown after each state name in Table G-1: [8,14,47,48,101,102,103,104].

Table G-1. WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
ARIZONA[illegible]																		
Navajo	Black Mesa Kayenta	Black Mesa No. [illegible]	1973	[illegible]	10.7	44.4	47.1	8.5	0.4	[illegible]	[illegible]	1.1	14.9	10,[illegible]	12,[illegible]	[illegible]	-	[illegible]
COLORADO[illegible]																		
Weld	Erie	Eagle	1947		[illegible]	[illegible]	[illegible]	4.7	0.4	4.9	[illegible]	[illegible]	15.4	9,[illegible]	12,710	2,[illegible]	-	-
"	"	"	1947		[illegible]	[illegible]	54.7	5.3	0.3	-	-	-	-	9,[illegible]	12,[illegible]	[illegible]	-	-
"	"	"	1947		22.4	41.4	53.4	5.2	0.3	-	-	-	-	9,830	12,660	2,[illegible]	-	-
"	"	"	1947		22.3	[illegible]	53.7	7.6	0.4	-	-	-	-	9,[illegible]	12,390	2,140	-	-
"	"	"	1949		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	9,810	12,[illegible]	[illegible]	-	-
"	"	"	1950		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	9,640	12,330	2,040	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	9,71[illegible]	12,[illegible]	2,[illegible]	-	-
"	"	Imperial	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	9,[illegible]	12,[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	9,[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,780	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	9,[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
Weld	Erie	Washington	1948		18.5	41.2	53.5	6.3	0.4	-	-	-	-	9,980	12,250	-	-	-
"	"	"	1947		15.5	39.6	54.3	5.4	0.3	-	-	-	-	10,[illegible]	12,620	-	-	-
"	"	"	1948		20.7	39.5	54.1	6.4	0.4	-	-	-	-	[illegible]	12,300	[illegible]	-	-
"	"	"	1949		20.0	38.7	54.4	6.9	0.5	-	-	-	-	[illegible]	12,380	2,070	-	-
"	"	"	1950		20.4	38.7	55.6	5.7	0.4	-	-	-	-	10,[illegible]	12,620	2,020	-	-
Weld	Fredrick	Graden	1948		20.0	39.3	55.2	5.5	0.4	-	-	-	-	9,950	12,440	-	-	-
Routt	Oak Creek	Edna	1947	Lennox	9.9	44.8	51.1	4.1	2.5	-	-	-	-	11,940	13,250	2,[illegible]	-	-
"	"	"	1949		8.7	44.3	51.5	4.2	2.2	-	-	-	-	12,070	13,220	-	-	-
"	"	"	1950		7.5	45.4	50.6	4.0	2.3	-	-	-	-	12,[illegible]	13,310	-	-	-
"	"	"	1947	Lennox	9.4	45.6	50.2	4.2	2.2	-	-	-	-	12,060	13,300	[illegible]	-	-
"	"	"	1947	Lennox	10.7	45.2	51.1	3.7	2.3	5.4	74.3	1.9	12.4	11,890	13,310	[illegible]	-	-
"	"	"	1949		8.1	42.9	51.0	6.1	2.3	-	-	-	-	11,860	12,900	-	-	-
"	"	"	1950		7.8	43.7	51.5	4.8	2.1	-	-	-	-	12,030	13,050	-	-	-
"	"	"	1950		9.0	44.4	50.4	5.2	2.3	-	-	-	-	11,920	13,100	2,060	-	-
"	"	"	1950		8.3	44.7	50.6	4.7	2.3	-	-	-	-	12,000	13,190	1,950	-	-
"	"	"	1947	Lennox	9.9	43.4	52.4	4.2	2.2	-	-	-	-	11,990	13,310	2,[illegible]	-	-
"	"	Annie's	1947		8.4	42.5	53.4	4.1	0.5	5.4	76.5	1.7	11.6	12,360	13,490	2,310	-	-
"	"	Pinnacle	1948		8.6	41.2	50.0	8.8	0.6	-	-	-	-	11,620	12,710	2,440	-	-
Routt	Routt	Keystone	1948	Pinnacle	6.9	40.7	52.9	6.4	0.6	-	-	-	-	12,320	13,230	2,550	-	-
"	"	"	1948	"	7.0	42.3	51.7	6.0	0.5	-	-	-	-	12,290	13,210	2,320	-	-
"	"	"	1948	"	7.1	42.0	51.6	6.4	0.6	-	-	-	-	12,240	13,180	2,570	-	-
"	"	"	1948	"	7.9	43.2	52.2	4.6	0.6	5.3	75.6	1.7	12.2	12,350	13,410	2,420	-	-
"	"	"	1947	"	10.4	42.7	52.6	4.7	0.5	-	-	-	-	12,030	13,470	2,460	-	-
"	"	"	1948	"	9.0	41.7	50.2	8.1	0.5	-	-	-	-	11,730	[illegible]	2,730	-	-
"	"	"	1950	"	6.3	41.8	53.5	4.7	0.6	-	-	-	-	12,290	13,300	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
Weld	[illegible]	Boulder Valley No. 3	1948	Laramie	24.9	39.9	55.3	4.8	0.3	4.7	72.8	1.6	15.[illegible]	9,390	12,510	2,080	-	-
"	"	"	1948		24.7	39.3	55.4	5.3	0.4	-	-	-	-	9,400	12,480	2,210	-	-
"	"	"	1948		24.6	39.1	53.7	7.2	0.7	-	-	-	-	9,270	12,290	1,970		
"	"	"	1948		22.5	38.8	54.2	7.0	0.6	-	-	-	-	9,530	12,300	1,970	-	-
"	"	"	1949		22.0	38.8	54.5	6.7	0.5	-	-	-	-	9,590	12,300	2,000	-	-
"	"	"	1950		25.1	38.7	55.3	6.0	0.4	-	-	-	-	9,300	12,420	2,110	-	-
"	"	"	1948		24.7	39.1	52.2	8.7	0.8	-	-	-	-	9,260	12,040	1,970	-	-
"	"	"	1948		23.3	39.0	53.5	7.5	0.9	-	-	-	-	9,470	12,190	2,040	-	-
"	"	"	1950		23.0	39.4	54.2	6.4	0.5	-	-	-	-	9,400	12,330	2,030	-	-
Routt	McGregor	Black Dan	1947	Wadge	12.7	42.4	49.6	8.0	0.6	5.0	71.0	1.8	13.6	10,860	12,440	2,680	-	-
"	"	"	1947	"	12.9	41.8	47.7	10.5	0.5	-	-	-	-	10,470	12,020	2,730	-	-
"	"	"	1947	"	14.5	42.9	48.2	8.9	0.1	-	-	-	-	10,430	12,200	2,470	-	-
"	"	"	1948	"	13.4	39.3	51.7	9.0	0.7	-	-	-	-	10,660	12,310	2,510	-	-
"	"	"	1949	"	12.4	37.6	49.8	12.6	0.5	-	-	-	-	10,180	11,620	2,530	-	-
"	"	"	1947	"	18.3	37.8	51.3	10.9	0.7	-	-	-	-	9,590	11,740	2,360	-	-
Routt	Mount Harris	Harris	1950	"	8.1	41.5	51.6	6.9	1.2	-	-	-	-	11,760	12,800	-	-	-
"	"	"	1950	"	8.5	40.1	52.6	7.3	0.5	-	-	-	-	11,630	12,710	-	-	-
"	"	"	1950	"	6.9	40.3	52.8	6.9	0.5	-	-	-	-	11,890	12,770	-	-	-
"	"	"	1949	"	8.7	42.1	50.0	7.9	0.5	-	-	-	-	11,540	12,640	-	-	-
"	"	"	1948	"	9.8	40.3	51.3	8.4	0.5	-	-	-	-	11,430	12,670	-	-	-
"	"	"	1948	"	8.2	39.0	52.5	8.5	0.5	-	-	-	-	11,570	12,600	-	-	-
"	"	"	1949	"	8.1	38.3	53.9	7.8	0.5	-	-	-	-	11,640	12,660	-	-	-
"	"	"	1950	"	8.1	40.3	52.1	7.6	0.5	-	-	-	-	11,480	12,710	-	-	-
"	"	"	1948	"	9.0	38.4	54.6	7.0	0.4	-	-	-	-	11,690	12,840	-	-	-
"	"	"	1949	"	8.0	41.9	50.3	7.8	0.5	-	-	-	-	11,590	12,600	-	-	-
"	"	"	1950	"	8.6	39.9	52.3	7.8	0.5	-	-	-	-	11,540	12,630	2,850	-	-
"	"	"	1948	"	8.1	39.1	53.0	7.9	0.5	-	-	-	-	11,420	12,600	2,910	-	-

Table B-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Date of analysis	Seam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Btu as received	Btu dry	[illegible] temperature, °F	[illegible] swelling index	[illegible] grindability index
COLORADO (continued)																		
Routt	Mount Harris	[illegible]	[illegible]	Wadge	10.8	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	11,400	[illegible]	-	-	-
Moffat	Axial	Red Wing	196[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.5	[illegible]	-	-	-	-	12,330	13,2[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	8.8	40.1	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1969	"	11.4	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1969	"	10.7	[illegible]	54.6	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
Moffat	Craig	Kerr	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	40.1	[illegible]	[illegible]	[illegible]	-	-	-	-	10,760	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	10,890	[illegible]	[illegible]	-	-
Moffat	[illegible]	[illegible]	[illegible]		[illegible]	39.4	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
Rio Blanco	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]*	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]*		
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Routt	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	41.8	[illegible]	[illegible]	1.4	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Bed	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, %: Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
Mesa	Palisade	Mount Garfield	[illegible]	Palisade	13.4	41.2	53.6	5.1	0.8	5.3	75.8	2.0	11.3	11,750	13,640	2,330	-	-
"	"	"	1947	"	[illegible]	41.5	52.5	6.0	0.6	-	-	-	-	11,230	11,370	2,680	-	-
"	"	"	1947	"	[illegible]	[illegible]	[illegible]	8.2	[illegible]	-	-	-	-	11,700	12,980	2,740	-	-
"	"	"	1947	"	10.1	38.5	[illegible]	[illegible]	0.9	-	-	-	-	11,490	12,720	2,710	-	-
"	"	"	1947	"	[illegible]	37.9	48.1	14.1	[illegible]	-	-	-	-	11,790	11,880	2,620	-	-
"	"	Palisade	1947	"	[illegible]	41.3	[illegible]	[illegible]	1.0	5.1	75.2	1.8	13.2	[illegible]	13,320	2,470	-	-
"	"	"	1947	"	9.8	40.6	49.7	9.7	1.1	-	-	-	-	11,930	12,930	[illegible]	-	-
"	"	"	1947	"	8.8	40.1	47.4	12.5	1.1	-	-	-	-	11,450	[illegible]	2,890	-	-
"	"	"	[illegible]	"	[illegible]	37.9	[illegible]	15.5	1.1	-	-	-	-	11,140	[illegible]	2,910	-	-
"	"	Riverside	[illegible]	"	7.1	[illegible]	50.9	9.7	1.0	5.1	72.5	1.8	9.9	12,040	12,960	2,590	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	1.0	-	-	-	-	11,640	12,940	2,470	-	-
"	"	"	1947	"	[illegible]	38.9	[illegible]	15.1	1.1	-	-	-	-	11,580	[illegible]	[illegible]	-	-
"	"	"	1947	"	6.4	39.6	[illegible]	13.9	1.1	-	-	-	-	[illegible]	12,170	2,880		
"	"	Wingate	1947	Cameo	7.8	38.4	47.8	13.8	0.7	-	-	-	-	[illegible]	12,210	2,910*		
"	"	"	1947	"	9.1	37.6	48.1	14.3	0.7	-	-	-	-	11,280	12,240	2,910*		
"	"	"	[illegible]	"	8.7	39.6	48.7	11.6	0.8	-	-	-	-	[illegible]	12,710	-	-	-
"	"	"	1947	"	7.1	[illegible]	47.8	13.5	0.9	4.9	68.8	1.5	10.4	11,240	12,190	2,860	-	-
Las Animas	Trinidad	[illegible]	[illegible]	Bear [illegible] No. 1	1.8	35.8	54.7	7.5	0.5	-	-	-	-	[illegible]	13,080	-	-	-
"	"	"	[illegible]	"	1.9	35.4	54.4	10.2	0.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	35.0	55.1	7.9	0.6	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	1.8	34.7	[illegible]	11.4	0.5	-	-	-	-	[illegible]	[illegible]	-	-	-
Mesa	Cameo	Cameo	1947	Cameo	7.4	39.9	[illegible]	8.7	0.6	4.9	[illegible]	1.5	10.2	12,110	13,070	2,540	-	-
"	"	"	1947	"	[illegible]	[illegible]	49.6	11.7	0.7	-	-	-	-	11,720	12,590	2,860	-	-
"	"	"		"	7.4	39.6	49.6	11.6	0.7	-	-	-	-	11,640	12,570	2,800	-	-
"	"	River View	1947	"	8.0	37.7	51.9	[illegible]	0.7	5.0	[illegible]	1.6	10.4	11,900	12,930	2,720	-	-

Table B-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

[illegible]

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %					Ultimate analysis, %				Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
COLORADO (continued)																		
Las Animas	Morley	[illegible]	[illegible]		2.1	35.8	[illegible]	16.2	0.7	-	-	-	-	11,970	12,260	2,940	-	-
"	"	"	1947		2.9	34.6	45.3	20.1	0.7	-	-	-	-	11,310	[illegible]	[illegible]	-	-
"	"	Rapson	1947		2.1	37.2	50.0	12.9	0.6	5.3	[illegible]	1.1	8.1	12,610	12,910	2,910*	-	-
"	"	"	[illegible]		2.2	37.5	51.8	10.7	0.6	-	-	-	-	12,950	13,240	-	-	-
"	"	"	1947		2.4	36.9	49.8	13.3	0.7	-	-	-	-	12,480	12,790	2,910*	-	-
"	"	"	1950		2.4	34.6	48.5	16.9	0.6	-	-	-	-	11,920	12,210	-	-	-
"	"	"	1950		2.2	35.3	48.4	16.3	0.5	-	-	-	-	12,070	12,340	2,910*	-	-
"	"	"	1947		3.0	35.5	47.8	16.7	0.7	-	-	-	-	11,910	12,270	2,910*	-	-
Las Animas	Starkville	Starkville No. 4	1947		[illegible]	30.9	52.6	16.5	0.7	-	-	-	-	12,370	12,750	2,910*	-	-
"	"	"	1947		1.2	31.4	52.3	16.3	0.7	4.8	71.8	1.3	5.1	12,650	12,800	2,910*	-	-
Las Animas	Trinidad	Baldy No. [illegible]	1947		1.7	32.2	53.3	14.5	0.6	4.8	72.1	1.2	6.8	12,690	12,840	2,880	-	-
"	"	"	1947		1.6	32.5	48.3	19.2	0.6	-	-	-	-	11,930	12,120	2,870	-	-
"	"	Peacock	1947		1.6	35.2	52.6	12.2	0.6	[illegible]	73.8	1.5	6.8	12,900	13,100	2,420	-	-
"	"	"	1947		1.3	35.6	49.0	15.4	0.6	-	-	-	-	12,400	12,560	2,870	-	-
"	"	R. and O.	1947	No. 3	1.6	28.3	49.1	22.6	0.5	-	-	-	-	[illegible]	11,700	2,910*	-	-
"	"	"	1947	"	2.1	30.6	50.3	19.1	0.6	4.7	69.0	1.2	5.4	12,080	12,340	2,910*	-	-
La Plata	Hesperus	Kinsletti	1948	Hesperus	4.5	41.0	54.6	4.4	1.4	5.4	73.1	1.8	8.9	13,460	14,090	2,210	-	-
"	"	"	1948	"	[illegible]	41.0	52.8	6.2	2.2	-	-	-	-	13,260	13,780	2,100	-	-
"	"	"	1948	"	3.7	41.0	51.7	7.3	2.6	-	-	-	-	13,050	13,550	2,200	-	-
"	"	"	1948	"	3.6	40.4	50.1	8.9	2.3	-	-	-	-	[illegible]	13,280	-	-	-
"	"	"	1949	"	3.3	39.7	51.1	9.2	2.4	-	-	-	-	12,830	13,270	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: [illegible] of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								COLORADO (continued)										
	Hesperus	Wright	1948	Hesperus	3.7	40.8	51.1	7.9	2.4	-	-	-	-	11,[illegible]	13,[illegible]	2,470	-	-
	"	"	1948	"	3.1	40.6	49.6	9.8	1.6	-	-	-	-	12,810	13,250	2,230	-	-
	"	"	1948	"	3.4	42.1	50.1	7.8	2.6	5.5	75.1	1.7	7.4	13,150	13,610	2,230	-	-
Las Animas	Boncarbo	Anchor	1947	Primero	1.8	33.9	55.9	10.2	0.6	5.3	76.1	1.5	6.8	13,120	13,360	2,250	-	-
"	"	"	1947	"	1.4	34.2	48.5	17.3	0.6	-	-	-	-	12,200	12,380	2,600	-	-
"	Delagua	Delagua	1947	Cass	2.4	36.0	46.9	17.1	0.7	5.2	68.5	1.4	7.1	11,990	12,290	2,680	-	-
"	Ludlow	Ludlow	1947	No. 2, & 3	1.5	33.1	50.3	16.6	0.6	4.9	70.0	1.2	6.7	12,160	12,350	2,910*	-	-
"	"	"	1948		1.7	35.4	51.1	13.5	0.7	-	-	-	-	12,770	12,990	-	-	-
"	"	"	1947		1.8	34.0	48.8	17.2	[illegible]	-	-	-	-	12,230	12,450	2,910*	-	-
"	"	"	1948		1.4	33.9	48.8	17.3	[illegible]	-	-	-	-	12,[illegible]	12,[illegible]	-	-	-
"	"	"	1950		1.4	31.5	50.1	18.4	0.6	-	-	-	-	12,110	12,280	2,910*	-	-
"	"	"	1947		2.2	32.7	45.5	21.8	0.7	-	-	-	-	11,430	11,680	2,910*	-	-
"	"	"			1.8	33.[illegible]	49.[illegible]	17.4	[illegible]	-	-	-	-	12,[illegible]	12,[illegible]	2,[illegible]	-	-
Jackson	Coalmont	Moore Strip No. 2	1947	Riach	20.8	43.4	50.6	6.0	0.5	5.0	69.8	1.5	17.2	9,620	12,150	2,230	-	-
La Plata	Durango	Peerless	1948		2.8	40.3	55.3	4.4	[illegible]	[illegible]	[illegible]	[illegible]	5.6	14,[illegible]	14,[illegible]	2,[illegible]	-	-
"	"	"	1948		2.7	38.1	52.1	9.8	0.7	-	-	-	-	13,250	13,[illegible]	2,[illegible]*	-	-
"	"	Victory	1948		2.5	39.3	55.3	5.4	1.[illegible]	[illegible]	79.[illegible]	1.5	6.6	13,[illegible]	14,[illegible]	2,030	-	-
"	"	"	1948		2.8	39.[illegible]	54.6	6.2	1.6	-	-	-	-	13,790	14,[illegible]	2,[illegible]	-	-
"	"	"	1948		2.6	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	13,500	13,[illegible]	2,[illegible]	-	-
"	"	"	1948		2.4	39.9	52.[illegible]	7.[illegible]	1.3	-	-	-	-	13,[illegible]	13,[illegible]	2,[illegible]	-	-
"	Hesperus	[illegible] Slip No. [illegible]	1948	Hesperus	4.1	42.[illegible]	53.[illegible]	4.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]	5.5	13,[illegible]	14,[illegible]	2,[illegible]	-	-
"	"	"	1948	"	4.1	40.[illegible]	[illegible]	[illegible]	1.1	-	-	-	-	12,[illegible]	13,[illegible]	2,[illegible]	-	-

Table 5-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal Field or Town	Mine Name	Mine Year of Analysis	Seam	Proximate analysis, % [illegible]	[illegible]	[illegible]	[illegible]	Ultimate analysis, % [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling Index	Hardgrove grindability Index
								(continued)										
La Plata	Hesperus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]*	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]*	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
		[illegible]	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"														
"	"	"	[illegible]	"														
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1947	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1949	[illegible] and [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
Huerfano	Walsenburg	[illegible]	[illegible]	Walsen	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	Morning Glory	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1947		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1952		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	[illegible]	1949	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Proximate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					COLORADO (continued)													
El Paso	Colorado Springs	Pike View	1948	Pike [illegible]	24.1	[illegible]	[illegible]	7.8	0.4	-	-	-	-	[illegible]	11,[illegible]	-	-	-
"	"	"	1949	"	24.2	42.1	[illegible]	7.7	0.4	-	-	-	-	9,070	11,[illegible]	-	-	-
"	"	"	1948	"	25.1	42.6	[illegible]	[illegible]	[illegible]	6.5	67.8	0.9	19.7	8,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	1948	"	18.2	43.1	49.3	7.4	0.4	-	-	-	-	9,[illegible]	11,[illegible]	-	-	-
"	"	"	1949	"	25.1	43.7	49.2	7.1	0.4	-	-	-	-	9,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	1948	"	24.9	42.7	49.1	[illegible]	[illegible]	-	-	-	-	9,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	1946	"	22.1	43.2	49.5	7.3	0.4	-	-	-	-	8,800	11,900	2,060	-	-
"	"	"	1948	"	24.2	40.9	48.9	10.2	0.5	-	-	-	-	8,[illegible]	[illegible]	2,100	-	-
Fremont	Florence	[illegible]	1947	Lower Coal O'Laughlin	3.4	37.[illegible]	[illegible]	14.4	[illegible]	5.[illegible]	[illegible]	1.1	12.3	10,[illegible]	[illegible]	2,[illegible]	-	-
"	"	Corley No.[illegible]	1947	"	5.1	39.[illegible]	[illegible]	10.7	0.6	-	-	-	-	10,[illegible]	11,[illegible]	-	-	-
"	"	"	1949	"	7.4	40.6	47.9	11.5	0.6	-	-	-	-	10,[illegible]	11,670	-	-	-
"	"	Pine Gulch	1950	"	7.6	39.7	52.4	7.9	0.9	-	-	-	-	11,[illegible]	12,[illegible]	-	-	-
"	"	"	19[illegible]	"	7.9	40.0	51.9	8.1	0.8	-	-	-	-	11,[illegible]	12,[illegible]	2,[illegible]	-	-
"	"	Vento	1950	"	9.6	38.7	52.6	8.6	0.5	-	-	-	-	11,180	12,370	-	-	-
"	"	"	1950	"	8.3	37.1	51.8	11.1	0.5	-	-	-	-	10,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	19[illegible]	"	9.3	37.7	52.7	11.6	0.5	-	-	-	-	10,[illegible]	11,[illegible]	2,[illegible]	-	-
Delta	Paonia	Delta W	1947		10.6	38.0	49.1	12.3	0.7	4.7	57.5	1.6	12.6	10,[illegible]	11,[illegible]	2,[illegible]*	-	-
"	"	"	1947		15.7	37.7	48.4	13.9	0.7	-	-	-	-	10,[illegible]	11,740	2,910*	-	-
"	"	"	1947		14.5	38.6	49.7	13.7	0.8	-	-	-	-	10,[illegible]	11,[illegible]	2,910*	-	-
"	"	Paonia Farmers	1947		9.2	42.3	54.[illegible]	3.7	0.6	5.4	77.6	1.7	11.0	12,[illegible]	13,[illegible]	2,700	-	-
"	"	"	1947		[illegible]	[illegible]	[illegible]	3.[illegible]	[illegible]	-	-	-	-	11,[illegible]	13,[illegible]	2,[illegible]	-	-
[illegible]	[illegible]	White Ash	19[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7,[illegible]	[illegible]	2,[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

[illegible]

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									COLORADO (continued)									
Delta	Cedaredge	Black Diamond	1949		13.3	38.0	53.3	5.7	0.6	5.2	71.1	1.6	17.8	10,940	12,620	2,910*	-	-
	"		1949		12.4	38.4	51.0	9.5	0.6	-	-	-	-	11,310	12,960	2,910*	-	-
	"		1949		13.6	38.0	52.0	10.0	0.7	-	-	-	-	10,680	12,370	2,910*	-	-
Delta	"	Raven Fairview	1947		15.7	38.4	50.3	11.3	0.6	4.9	68.5	1.6	13.2	10,130	12,000	2,910*	-	-
"	"	"	1946		11.9	39.2	47.3	13.5	0.6	-	-	-	-	10,330	11,730	-	-	-
"	"	"	1947		15.3	38.1	49.8	12.1	0.6	-	-	-	-	10,070	11,890	2,910*	-	-
"	"	"	1947		16.3	37.9	50.1	12.0	0.8	-	-	-	-	9,940	11,880	[illegible]	-	-
"	"	Red Canyon	1947	Red Canon	14.1	40.0	54.8	5.2	0.7	5.3	73.8	1.7	13.1	11,250	13,090	2,750	-	-
"	"	"	1947	"	14.5	40.2	54.1	5.7	0.7	-	-	-	-	11,140	13,020	2,590	-	-
"	"	"	1947	"	13.5	39.8	52.9	7.3	0.7	-	-	-	-	11,110	12,850	2,640		
"	"	"	1947	"	20.0	39.3	52.7	8.0	0.8	-	-	-	-	10,170	12,840	2,700	-	-
"	"	"	1947	"	17.5	39.1	53.1	7.8	0.7	-	-	-	-	10,400	12,630	2,570	-	-
"	"	Top	1947		14.6	39.4	55.3	5.3	0.6	-	-	-	-	11,1[illegible]	13,090	2,510	-	-
"		"	1947		14.6	40.4	54.3	5.3	0.6	5.2	73.7	1.7	13.5	11,180	13,080	2,510	-	-
"	"	"	1947		13.5	39.6	53.1	7.3	0.6	-	-	-	-	11,030	12,750	2,560	-	-
"	"	"	1947		15.4	38.3	54.7	7.0	0.7	-	-	-	-	10,860	12,820	2,520	-	-
"	"	"	1947		18.6	38.4	54.2	7.4	0.6	-	-	-	-	10,300	12,680	2,540	-	-
Gunnison	Somerset	Bear	1948	C	5.4	41.1	53.4	5.5	0.5	5.5	76.3	1.7	10.5	12,570	13,600	2,630	-	-
"	"	"	1949	"	5.3	40.9	53.8	5.3	0.5	-	-	-	-	12,950	13,700	-	-	-
"	"	"	1947	"	4.5	41.9	54.9	3.2	0.4	-	-	-	-	13,180	14,000	-	-	-
"	"	"	1948	"	5.4	41.3	52.9	5.8	0.5	-	-	-	-	12,900	13,630	2,720	-	-
"	"	"	1948	"	5.2	40.0	52.9	7.1	0.5	-	-	-	-	12,770	13,460	2,650	-	-
"	"	"	1947	"	5.8	41.1	53.2	5.7	0.5	-	-	-	-	12,810	13,600	2,610	-	-
"	"	"	1948	"	5.3	40.5	52.9	6.6	0.5	-	-	-	-	12,800	13,520	2,570	-	-
"	"	Edwards	1948	B	4.8	40.9	49.2	9.9	0.4	-	-	-	-	12,300	12,920	-	-	-
"	"	"	1948	B	6.0	40.5	50.9	9.1	0.4	-	-	-	-	12,480	13,140	2,400	-	-
"	"	Hawks Nest	1948		5.3	40.6	53.9	5.5	0.5	-	-	-	-	12,910	13,630	2,400	-	-

Table 3-1 (Continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

[illegible]

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
							COLORADO (continued)											
Boulder	Louisville	Centennial	1948	Laramie	17.9	35.6	56.8	7.6	0.4	-	-	-	-	10,030	12,220	-	-	-
Crown	Superior		1947		19.5	39.3	53.5	7.2	.3	-	-	-	-	9,750	12,110	2,030	-	-
"	"		1947		18.5	37.9	54.8	7.3	.4	-	-	-	-	10,040	12,320	2,060	-	-
"	"		1947		19.6	39.2	54.1	6.7	.4	-	-	-	-	9,790	12,180	2,000	-	-
"	"		1947		19.2	39.9	52.8	7.3	.3	-	-	-	-	9,800	12,140	2,030	-	-
"	"		1947		18.8	38.4	53.9	7.7	.4	-	-	-	-	9,910	12,210	2,050	-	-
Delta	Cedaredge	Black Diamond	1949		13.3	38.2	53.1	8.7	.6	5.2	71.1	1.6	12.8	10,940	12,620	-	-	-
"	"	"	1949		12.4	38.6	51.9	9.5	.6	-	-	-	-	11,010	12,560	-	-	-
"	"	"	1949		13.6	38.0	52.0	10.0	.7	-	-	-	-	10,680	12,370	-	-	-
"	"	Maven Fairview	1947		15.4	38.4	50.3	11.3	.6	4.8	68.5	1.6	13.2	10,130	12,020	-	-	-
"	"	"	1948		11.9	39.2	47.3	13.5	.6	-	-	-	-	10,330	11,730	-	-	-
"	"	"	1947		15.3	38.1	49.8	12.1	.6	-	-	-	-	10,070	11,890	2,910	-	-
"	"	"	1947		16.3	37.9	50.1	12.0	.8	-	-	-	-	9,940	11,880	2,680	-	-
"	"	Red Canon	1947	Red Canon	14.1	40.0	54.8	5.2	.4	5.3	74.3	1.7	13.1	11,250	13,090	2,750	-	-
"	"	"	1947	"	14.5	40.2	54.1	5.7	.7	-	-	-	-	11,140	13,030	2,590	-	-
"	"	"	1947	"	13.5	39.8	52.9	7.3	.7	-	-	-	-	11,110	12,850	2,640	-	-
"	"	"	1947	"	20.0	39.3	52.7	8.0	.9	-	-	-	-	10,120	12,640	2,700	-	-
"	"	"	1947	"	17.5	39.1	53.1	7.8	.7	-	-	-	-	10,420	12,630	2,570	-	-
"	"	Top	1947		14.6	39.4	55.3	5.3	.6	-	-	-	-	11,180	13,090	2,510	-	-
"	"	"	1947		14.5	40.4	54.3	5.3	.6	5.2	73.7	1.7	13.5	11,180	13,080	2,510	-	-
"	"	"	1947		13.5	39.6	53.1	7.3	.6	-	-	-	-	11,030	12,750	2,660	-	-
"	"	"	1947		15.4	38.1	54.7	7.2	.7	-	-	-	-	10,660	12,600	2,520	-	-
"	"	"	1947		18.6	38.4	54.2	7.4	.8	-	-	-	-	10,320	12,680	2,540	-	-
"	"	Delta "B"	1947		10.6	38.0	49.1	12.9	.7	4.7	68.5	1.6	12.6	10,610	11,870	2,910	-	-
"	"	"	1947		10.7	37.7	48.4	13.9	.7	-	-	-	-	10,490	11,740	2,910	-	-
"	"	"	1947		14.6	38.6	48.7	12.7	.8	-	-	-	-	10,100	11,830	2,910	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of sample	Seam	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, %: Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
[illegible]	[illegible]	[illegible] Thirteen	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.8	[illegible]	12,4[illegible]	13,4[illegible]	2,[illegible]	-	-
"		"	1947		9.2	40.[illegible]	54.[illegible]	3.8	.5	-	-	-	-	12,[illegible]	13,[illegible]	2,760	-	-
Elbert		White Ash	[illegible]		22.9	[illegible]	40.8	12.7	.7	6.1	54.8	1.1	18.7	7,3[illegible]	9,4[illegible]	2,2[illegible]	-	-
El Paso	Colorado Springs	City No. 4	1947	[illegible]	26.7	44.9	47.6	8.4	.5	-	-	-	-	8,460	11,500	2,170	-	-
"	"	"	1947	"	26.7	41.7	48.[illegible]	[illegible]	.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	1947	"	26.9	[illegible]	45.8	11.7	.4	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1947	"	25.2	44.1	45.3	10.6	.5	-	-	-	-	[illegible]	11,1[illegible]	[illegible]	-	-
"	"	"	1947	"	26.2	41.[illegible]	46.5	12.4	.4	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
		Franceville	1947	"	[illegible]	41.8	49.[illegible]	8.9	.4	[illegible]	[illegible]	[illegible]	[illegible]	9,040	11,[illegible]	[illegible]	-	-
"	"	"	1947	"	[illegible]	40.7	47.3	12.0	.4	-	-	-	-	8,830	11,860	2,240	-	-
"	"	"	1947	"	[illegible]	[illegible]	[illegible]	15.[illegible]	.4	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1947	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	Pine View	1948	"	26.1	43.0	49.4	7.6	.4	-	-	-	-	8,6[illegible]	11,860	-	-	-
"	"	"	[illegible]	"	26.2	[illegible]	50.0	[illegible]	.6	-	-	-	-	[illegible]	11,[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
[illegible]	[illegible]	[illegible]	[illegible]	Lower [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
"	"	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	11,[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu, as received	Btu, dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								COLORADO (continued)										
Fremont	Florence	Curly No.6	1944		7.4	40.6	47.9	11.5	.5	-	-	-	-	10,810	11,670	-	-	-
"	"	Pine Gulch	1950		7.8	39.7	52.4	7.9	.3	-	-	-	-	11,040	12,000	-	-	-
"	"	"	1950		7.9	40.0	51.9	8.1	.8	-	-	-	-	11,500	12,490	2,290	-	-
"	"	Vento	1950		9.6	38.8	52.6	8.6	.5	-	-	-	-	11,180	12,370	-	-	-
"	"	"	1950		8.8	37.1	51.6	11.3	.5	-	-	-	-	10,890	11,940	2,310	-	-
"	"	"	1950		8.9	37.7	50.7	11.6	.5	-	-	-	-	10,840	11,900	2,290	-	-
Garfield	Glenwood Springs	South Canon No.1	1947	D	6.7	42.8	54.9	2.3	.5	5.4	76.9	2.0	12.9	12,780	13,690	2,320	-	-
"	"	"	1947	"	6.6	42.7	53.8	3.5	.6	-	-	-	-	12,700	13,600	2,400	-	-
"	"	"	1947	"	6.4	42.7	53.7	3.6	.6	-	-	-	-	12,650	13,520	2,470	-	-
"	"	Sunlight	1947	"	5.5	42.8	53.7	3.5	.7	5.5	76.8	1.8	11.7	12,980	13,730	2,380	-	-
"	"	"	1950	"	5.2	39.9	49.6	10.5	1.5	-	-	-	-	11,840	12,490	2,220	-	-
"	"	"	1947	"	7.5	42.2	53.7	4.1	.8	-	-	-	-	12,560	13,570	2,710	-	-
Gunnison	Baldwin	Baldwin Star	1947		12.7	41.7	52.6	5.7	0.9	5.3	72.9	1.6	13.6	11,360	13,010	2,200	-	-
"	"	"	1947		12.3	42.4	50.9	6.7	1.1	-	-	-	-	11,290	12,880	2,130	-	-
"	"	Kubler (New Baldwin)	1947		9.0	38.7	55.4	5.9	.5	5.2	75.2	1.6	11.6	12,050	13,240	2,330	-	-
"	"	"	1947		8.5	38.1	55.7	6.0	.4	-	-	-	-	12,240	13,370	2,310	-	-
"	"	"	1947		9.0	38.5	52.4	9.1	.4	-	-	-	-	11,550	12,690	2,380	-	-
"	"	[illegible] Mine	1947	No.1	10.7	41.6	50.6	7.8	.8	-	-	-	-	11,460	12,840	2,290	-	-
"	"	"	1947	"	10.3	41.8	53.1	5.1	.6	-	-	-	-	11,630	13,260	2,270	-	-
"	"	"	1947	"	10.6	40.9	53.4	5.7	.8	-	-	-	-	11,810	13,120	2,190	-	-
"	"	Bear	1947	C	5.6	41.1	53.4	5.5	.5	5.8	76.1	1.7	10.5	12,840	13,600	2,130	-	-
"	"	"	1948	"	5.3	40.9	53.8	5.3	.5	-	-	-	-	12,980	13,700	-	-	-
"	"	"	1949	"	4.5	41.9	54.9	3.2	.4	-	-	-	-	13,380	14,000	-	-	-
"	"	"	1947	"	5.4	41.3	52.9	5.8	.5	-	-	-	-	12,900	13,630	2,720	-	-
"	"	"	1948	"	5.2	40.0	52.9	7.1	.5	-	-	-	-	12,760	13,460	2,650	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
							COLORADO (continued)											
Gunnison	Baldwin	Bear	1947	C	5.8	41.1	53.2	5.7	.5	-	-	-	-	12,810	13,600	2,610	-	-
"	"	"	1948	"	5.3	40.5	52.9	6.6	.5	-	-	-	-	12,800	13,520	2,570	-	-
"	"	Edward's	1948	D	4.5	40.9	49.2	9.9	.4	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1949	"	5.0	40.0	50.9	9.1	.4	-	-	-	-	12,480	13,140	2,400	-	-
"	"	Hawk's Nest	1948		5.3	40.6	53.9	5.5	.5	-	-	-	-	12,910	13,630	2,400	-	-
"	"	Oliver's No. 2	1947	D	5.8	40.9	53.7	5.4	.5	5.2	77.2	1.6	10.1	12,800	13,580	2,460	-	-
"	"	"	1949		5.9	40.4	52.6	7.0	.5	-	-	-	-	12,540	13,320	-	-	-
"	"	"	1947	D	5.8	40.1	52.6	7.3	.4	-	-	-	-	12,520	13,290	2,910	-	-
"	"	"	1948		5.7	38.9	50.7	10.4	.6	-	-	-	-	12,090	12,820	-	-	-
"	"	"	1949		5.5	39.8	50.5	9.7	.6	-	-	-	-	12,170	13,750	-	-	-
"	"	"	1947	D	6.5	40.4	52.0	7.6	.5	-	-	-	-	12,390	[illegible]	2,790	-	-
"	Somerset	Somerset	1947	B	5.2	39.0	52.2	8.8	.6	5.2	74.2	1.5	9.7	12,560	13,250	2,440	-	-
"	"	"	1947		5.1	38.2	51.6	10.2	.5	-	-	-	-	12,340	13,010	2,520	-	-
"	"	"	1947		6.0	39.6	51.5	8.9	.5	-	-	-	-	12,410	13,200	2,570	-	-
"	"	"	1948	B & C	5.4	38.1	48.1	13.8	.5	-	-	-	-	[illegible]	[illegible]	2,290	-	-
Jackson	Coalmont	Moore Strip No.2	1947	Riach	20.3	41.4	50.6	6.0	.5	5.9	69.8	1.5	17.2	9,620	12,150	2,230	-	-
Huerfano	Walsenburg	Loma Park	1949	Walsen	5.5	35.2	47.0	17.8	1.3	-	-	-	-	10,060	10,650	2,490	-	-
"	"	Morning Glory	1947	Upper Robinson	5.6	41.3	50.0	8.7	.6	4.9	72.8	1.2	12.1	12,000	12,710	2,500	-	-
"	"	"	1947	"	5.9	39.4	50.2	10.4	.5	-	-	-	-	11,970	12,500	2,470	-	-
"	"	"	1948	"	6.1	37.3	54.2	8.5	.5	-	-	-	-	12,090	12,860	-	-	-
"	"	"	1950	"	4.4	38.2	52.1	9.7	.6	-	-	-	-	12,100	12,660	-	-	-
"	"	"	1949	"	4.5	38.1	50.2	11.7	.6	-	-	-	-	11,880	12,440	-	-	-
"	"	"	1950	"	3.8	37.7	51.2	11.3	.6	-	-	-	-	12,100	12,680	-	-	-
"	"	"	1947	"	5.9	37.1	46.2	14.7	.5	-	-	-	-	11,130	[illegible]	2,450	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, %: Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
Huerfano	Walsenburg	Ravenwood	1949	Cameron	3.6	34.4	51.6	10.4	.8	-	-	-	-	12,480	12,950	2,370	-	-
"	"	"	1949	"	3.1	35.2	51.7	9.[illegible]	.7	-	-	-	-	12,720	13,120	-	-	-
"	"	"	1950	"	5.5	35.5	50.7	8.4	.6	-	-	-	-	12,040	12,730	-	-	-
La Plata	Durango	Peerless	1948		2.8	39.9	55.9	4.2	.8	5.4	83.0	1.6	5.0	14,010	14,410	2,860	-	-
"	"	"	1948		2.7	35.1	52.9	9.0	.7	-	-	-	-	13,280	13,650	2,910	-	-
"	"	Victory	1948		2.5	39.3	55.3	5.4	1.1	5.6	79.4	1.5	6.6	13,950	14,320	2,930	-	-
"	"	"	1948	"	2.4	38.9	54.4	6.7	1.0	-	-	-	-	13,790	14,140	2,490	-	-
"	"	"	1948		2.6	35.4	54.0	7.7	1.6	-	-	-	-	13,600	13,970	2,600	-	-
"	"	"	1948		2.9	39.9	[illegible]	7.9	1.3	-	-	-	-	13,510	13,900	2,670	-	-
La Plata	Hesperus	Coal King No. 1	1948	Hesperus	4.1	37.3	53.7	4.3	.8	5.6	79.0	1.8	8.8	13,640	14,230	2,820	-	-
"	"	"	1948		4.1	40.0	50.8	9.2	1.1	-	-	-	-	12,860	13,910	2,520	-	-
"	"	"	1948		4.1	41.1	54.1	4.7	.7	5.5	78.1	1.7	9.1	13,520	14,090	2,910	-	-
"	"	Coal King No. 2	1948		3.8	40.5	51.9	7.7	.8	-	-	-	-	13,110	13,630	2,910	-	-
"	"	"	1948		3.8	-	-	8.9	1.2	-	-	-	-	12,950	13,460	2,190	-	-
"	"	"	1948		5.2	-	-	5.6	1.1	5.1	77.2	1.7	9.1	13,210	13,930	2,500	-	-
"	"	Hay Gulch No. 2	1948		6.9	-	-	12.6	2.0	-	-	-	-	11,690	12,490	130	-	-
"	"	"	1948		8.5	-	-	16.5	1.9	-	-	-	-	10,860	11,870	2,180	-	-
"	"	"	1948		4.5	-	-	4.4	1.4	5.4	78.1	1.8	8.9	13,460	14,090	2,210	-	-
"	"	Minoletti	1948		3.8	-	-	6.2	2.2	-	-	-	-	13,260	13,780	2,150	-	-
"	"	"	1948		3.7	-	-	7.3	2.6	-	-	-	-	13,050	13,550	2,200	-	-
"	"	"	1948		3.6	-	-	8.9	2.3	-	-	-	-	12,800	13,280	-	-	-
"	"	"	1949		3.3	-	-	9.2	2.4	-	-	-	-	12,830	13,270	-	-	-
"	"	"	1948		3.7	-	-	7.9	2.4	-	-	-	-	13,050	13,560	2,470	-	-
"	"	Wright No. 2	1948		3.3	-	-	9.8	3.6	-	-	-	-	12,810	13,250	2,230	-	-
"	"	"	1948		3.5	37.1	53.1	7.8	3.6	5.4	78.1	1.7	7.4	13,150	13,610	2,730	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine			Proximate analysis, %					Ultimate analysis, %				Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
							COLORADO (continued)											
Las Animas	Boncarbo	Anchor	1947	Primero	1.8	33.9	55.9	10.2	.6	4.8	76.1	1.5	6.8	13,120	13,360	2,250	-	-
"	"	"	1947	"	1.4	34.2	48.5	17.3	.6	-	-	-	-	12,200	12,480	2,680	-	-
"	Delagua	Delagua	1947	Cass	2.6	36.0	46.9	17.1	.7	5.0	68.5	1.4	7.3	11,930	12,240	2,680	-	-
"	"	Ludlow	1947	Nos. 2 & 3	1.5	35.1	48.3	16.6	.6	4.9	70.0	1.2	6.7	12,360	12,550	2,910	-	-
"	"	"	1948	"	1.7	35.4	51.1	13.5	.7	-	-	-	-	12,770	12,990	-	-	-
"	"	"	1947	"	1.8	34.0	48.8	17.2	.6	-	-	-	-	12,230	12,450	2,910	-	-
"	"	"	1948	"	1.4	33.9	48.8	17.3	.8	-	-	-	-	12,280	12,450	-	-	-
"	"	"	1950	"	1.4	31.5	50.1	18.4	.6	-	-	-	-	12,110	12,280	2,910	-	-
"	"	"	1947	"	2.2	32.7	45.5	2.18	.7	-	-	-	-	11,430	11,680	2,910	-	-
"	"	"	1948	"	1.8	33.6	49.0	17.4	.7	-	-	-	-	12,160	12,380	2,890	-	-
"	Rugby	Kenneth	1947		2.2	35.6	51.6	12.8	.6	-	-	-	-	12,440	12,730	2,910	-	-
"	"	"	1949		1.8	35.5	50.8	13.7	.6	-	-	-	-	12,430	12,650	-	-	-
"	"	"	1947		2.2	36.8	50.8	12.4	.5	5.0	72.9	1.2	8.0	12,550	12,840	2,890	-	-
"	"	"	1948		2.1	36.2	50.5	13.3	.5	-	-	-	-	12,500	12,770	-	-	-
"	"	"	1947		2.3	35.8	48.0	16.2	.5	-	-	-	-	11,970	12,260	2,840	-	-
"	"	"	1947		2.9	34.6	45.3	20.1	.7	-	-	-	-	11,310	11,650	2,680	-	-
"	"	Rapson	1947		2.3	37.2	50.0	12.8	.6	5.0	72.2	1.3	8.1	12,610	12,910	2,910	-	-
"	"	"	1949		2.2	33.5	51.8	10.7	.6	-	-	-	-	12,950	13,240	-	-	-
"	"	"	1947		2.4	36.9	49.8	13.3	.7	-	-	-	-	12,480	12,790	2,910	-	-
"	"	"	1950		2.4	34.6	48.5	16.9	.6	-	-	-	-	11,920	12,210	-	-	-
"	"	"	1950		2.2	35.3	48.9	16.3	.5	-	-	-	-	12,070	12,340	2,910	-	-
"	"	"	1947		2.9	35.5	47.8	16.7	.7	-	-	-	-	11,910	12,270	2,910	-	-
"	Stark-ville	Stark-ville No.4	1947		1.4	30.9	52.6	16.5	.7	-	-	-	-	12,570	12,750	2,910	-	-
"	"	"	1947		1.2	31.4	52.3	16.3	.7	4.8	71.8	1.3	5.1	12,660	12,800	2,910	-	-
"	Trinidad	Baldy No.2	1947		1.7	32.2	53.3	14.5	.6	4.8	72.1	1.2	6.8	12,630	12,940	2,880	-	-
"	"	"	1947		1.8	32.5	48.3	19.2	.6	-	-	-	-	11,930	12,120	2,870	-	-
"	"	Frederick	1947		1.6	35.2	52.6	12.2	.6	5.1	73.8	1.5	6.8	12,900	13,100	2,420	-	-

Table II-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Ultimate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								COLORADO (continued)										
Las Animas	Trinidad	Peacock	1947		1.1	35.4	49.0	15.5	.5	-	-	-	-	11,410	12,560	2,870	-	-
"	"	R & I	1947	No. 4	1.5	27.1	49.1	22.6	.5	-	-	-	-	11,000	11,170	[illegible]	-	-
"	"	"	1947	"	2.1	35.5	50.3	12.1	.8	4.7	69.5	1.2	5.4	12,080	12,340	2,870	-	-
Las Animas	Valleros	Bear Canon No.6	1948		1.8	35.8	54.7	8.1	0.5	-	-	-	-	13,440	13,680	-	-	-
"	"	"	1949		1.9	35.3	52.4	10.2	.6	-	-	-	-	13,190	13,440	-	-	-
"	"	"	1948		1.5	35.0	56.1	9.9	.6	-	-	-	-	13,350	13,550	-	-	-
"	"	"	1948		1.8	34.7	53.9	11.4	.5	-	-	-	-	13,230	13,470	-	-	-
Mesa	Cameo	Cameo	1947	Cameo	7.4	33.8	52.7	8.0	.6	4.8	74.5	1.5	10.2	12,110	13,070	2,640	-	-
"	"	"	1947	"	6.9	33.7	49.6	11.7	.7	-	-	-	-	11,750	12,570	2,860	-	-
"	"	"	1947	"	7.4	35.8	49.6	11.6	.7	-	-	-	-	11,640	12,570	2,830	-	-
"	"	River-View	1947	"	8.0	30.7	51.9	9.4	.7	5.0	72.9	1.6	10.4	11,900	12,930	2,700	-	-
"	Fruita	Hidden Treasure	1947	Palisade	8.1	39.5	46.7	5.8	.7	5.4	76.2	1.9	10.1	12,410	13,360	2,690	-	-
"	"	Hy-grade	1947	"	9.2	33.4	50.7	7.2	.4	5.1	75.1	1.5	15.2	11,100	11,320	2,570	-	-
"	"	"	1947	"	8.5	33.5	52.0	8.5	.5	-	-	-	-	11,290	11,970	2,570	-	-
"	"	"	1947	"	5.5	38.6	45.7	11.4	.6	-	-	-	-	11,720	12,400	2,690	-	-
"	"	"	1947	"	8.6	36.5	47.8	15.7	.8	-	-	-	-	10,950	11,980	2,510	-	-
"	Grand Junction	Monarch	1947	"	3.4	41.4	49.4	9.2	.6	5.2	72.5	1.7	10.5	11,740	12,440	1,590	-	-
"	"	"	1947	"	6.8	34.0	45.4	15.8	.7	-	-	-	-	11,410	12,090	2,750	-	-
"	"	"	1947	"	7.1	35.7	33.9	23.3	1.0	-	-	-	-	9,440	10,340	2,430	-	-
"	Palisade	Mount Garfield		"	10.4	41.3	53.5	5.3	.8	5.1	75.8	1.6	11.3	12,050	13,440	2,330	-	-
"	"	"		"	10.7	41.5	52.5	5.0	.8	-	-	-	-	12,130	13,170	2,590	-	-
"	"	"		"	9.9	40.2	51.6	8.3	.8	-	-	-	-	11,700	12,980	2,750	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, F°	Free swelling index	Hardgrove grindability index
									COLORADO (continued)									
Mesa	Palisade	Mount Garfield		Palisade	10.1	39.5	51.0	9.5	.9	-	-	-	-	11,440	12,720	2,730	-	-
"	"	"		"	9.2	37.8	48.1	14.1	1.0	-	-	-	-	10,780	11,880	2,620	-	-
"	"	Palisade		"	8.3	41.3	51.9	6.8	.8	5.3	75.0	1.9	10.2	12,220	13,320	2,470	-	-
"	"	"		"	7.8	40.6	49.7	9.7	1.1	-	-	-	-	11,920	12,930	2,510	-	-
"	"	"		"	8.5	40.1	47.4	12.5	1.1	-	-	-	-	11,450	12,510	2,390	-	-
"	"	"		"	7.4	38.3	46.2	15.5	1.1	-	-	-	-	11,140	12,020	2,310	-	-
"	"	Riverside		"	7.1	39.6	50.8	9.6	1.0	5.1	72.5	1.9	9.9	12,040	12,960	2,590	-	-
"	"	"		"	6.3	39.5	47.5	13.0	1.4	-	-	-	-	11,640	12,430	2,470	-	-
"	"	"		"	6.5	38.9	48.0	13.1	1.6	-	-	-	-	11,580	12,390	2,220	-	-
"	"	"		"	6.4	38.6	47.5	13.9	1.1	-	-	-	-	11,390	12,170	2,380	-	-
Las Animas	Palisade	Winger	1944	Cameo	7.8	38.4	47.8	13.8	.7	-	-	-	-	11,260	12,210	2,910	-	-
"	"	"	1944	"	7.1	37.6	48.1	14.3	.7	-	-	-	-	11,280	12,140	2,910	-	-
"	"	"	1950	"	7.2	39.5	49.2	11.0	.8	-	-	-	-	11,7[illegible]	12,710	-	-	-
"	"	"	1947	"	7.8	38.7	47.8	13.5	.9	4.9	68.8	1.5	10.4	11,240	12,190	2,860	-	-
Moffat	Axial	Red Wing	1950	Collom	9.3	45.3	51.2	3.5	.2	-	-	-	-	12,030	13,270	-	-	-
"	"	"	1949	"	9.2	43.6	53.2	3.2	.4	-	-	-	-	11,960	13,170	-	-	-
"	"	"	1948	"	8.5	40.1	56.3	3.6	.3	-	-	-	-	12,120	13,250	-	-	-
"	"	"	1948	"	11.4	39.3	55.7	5.0	.4	-	-	-	-	11,440	12,910	-	-	-
"	"	"	1949	"	10.7	39.3	54.6	6.1	.5	-	-	-	-	11,400	12,770	2,520	-	-
Moffat	Craig	Knez	1947		15.1	39.2	54.3	5.9	.4	5.0	72.8	..7	14.2	10,660	12,560	2,380	-	-
"	"	"	1947		14.2	38.3	55.6	6.1	.3	-	-	-	-	10,760	12,530	2,380		
"	"	"	1947		13.8	39.0	53.6	7.4	.3	-	-	-	-	10,670	12,380	2,400	-	-
"	"	"	1947		13.4	37.4	53.2	9.4	.4	-	-	-	-	10,390	12,030	2,560	-	-
Moffat	Zilt	Harvey Gap	1948		4.1	39.4	50.0	10.6	2.0	-	-	-	-	12,200	12,770	2,180	-	-
"	"	"	1950		7.9	38.2	49.4	11.8	2.1	-	-	-	-	[illegible]	12,570	2,170	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Bed	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature (deg. F)	Free swelling index	Hardgrove grindability index
					COLORADO (continued)													
Rio Blanco	[illegible]	[illegible]	[illegible]		11.0	44.8	52.7	6.3	.7	-	-	-	-	11,520	12,710	[illegible]	-	-
"	"	"	1967		11.2	40.6	51.4	7.0	.5	-	-	-	-	11,410	12,880	280	-	-
"	"	"	1967		11.0	40.4	51.7	5.6	.8	5.1	78.1	1.1	12.3	11,320	12,710	2,840	-	-
Routt	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	12,330	[illegible]	[illegible]	-	-
"	"	"	1968		7.4	41.5	50.6	7.0	[illegible]	-	-	-	-	12,070	13,010	[illegible]	-	-
"	"	"	[illegible]		7.1	41.6	47.7	10.7	[illegible]	-	-	-	-	11,610	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	49.2	10.8	[illegible]	-	-	-	-	11,090	12,530	[illegible]	-	-
"	"	"	[illegible]		7.4	39.8	47.8	12.4	[illegible]	-	-	-	-	[illegible]	12,240	[illegible]	-	-
"	"	"	[illegible]		8.2	40.9	49.4	9.7	1.4	-	-	-	-	11,590	[illegible]	2,310	-	-
Routt	[illegible]	[illegible]		Wadge	[illegible]	42.4	49.6	8.0	.6	[illegible]	[illegible]	1.8	13.6	10,860	12,440	[illegible]	-	-
"	"	"		"	12.9	41.5	47.7	10.5	.5	-	-	-	-	10,470	[illegible]	[illegible]	-	-
"	"	"		"	14.5	40.9	48.2	8.9	.6	-	-	-	-	10,430	12,200	2,470	-	-
"	"	"		"	[illegible]	[illegible]	[illegible]	9.0	[illegible]	-	-	-	-	10,660	[illegible]	[illegible]	-	-
"	"	"		"	[illegible]	37.6	49.5	12.8	.5	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"		"	18.3	37.8	51.3	10.9	.7	-	-	-	-	9,290	11,740	2,860	-	-
Routt	[illegible]	[illegible]	[illegible]	Wadge	[illegible]	[illegible]	[illegible]	6.9	[illegible]	-	-	-	-	11,760	12,800	-	-	-
"	"	"	[illegible]	"	[illegible]	40.1	[illegible]	7.3	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	6.9	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	7.9	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	40.3	52.1	8.4	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1948	"	[illegible]	39.0	[illegible]	[illegible]	.5	-	-	-	-	11,570	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	38.8	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	11,690	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1963	"	[illegible]	39.8	[illegible]	[illegible]	.5	-	-	-	-	11,590	[illegible]	[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %					Ultimate analysis, %				Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
					COLORADO (continued)													
Routt	Mount Harris	Harris	1945	Wadge	8.9	38.7	53.3	7.9	.5	-	-	-	-	11,480	12,600	2,915		
"	"	"	1950	"	11.6	35.8	52.8	4.7	.5	-	-	-	-	11,420	12,770	-	-	-
Routt	Oak Creek	Edna	1947	Lennox	5.5	44.8	51.1	4.1	2.5	-	-	-	-	11,940	13,250	2,000	-	-
"	"	"	1952		8.7	44.1	51.5	4.2	2.2	-	-	-	-	12,070	13,220	-	-	-
"	"	"	1952		7.5	45.4	50.6	4.0	2.3	-	-	-	-	12,300	13,310	-	-	-
"	"	"	1947	Lennox	9.4	45.6	50.2	4.2	2.2	-	-	-	-	12,060	13,350	2,050	-	-
"	"	"	1947	"	10.7	45.2	51.1	3.7	2.3	5.4	76.3	1.9	12.6	11,[illegible]	13,310	2,0[illegible]	-	-
"	"	"	1949		8.1	42.9	51.0	6.1	2.3	-	-	-	-	11,860	13,400	-	-	-
"	"	"	1950		7.8	43.7	51.5	4.8	2.1	-	-	-	-	12,030	13,050	-	-	-
"	"	"	1950		9.0	44.4	50.4	5.2	2.3	-	-	-	-	11,920	13,100	2,250	-	-
"	"	"	1950		8.9	44.7	50.6	4.7	2.3	-	-	-	-	12,020	13,190	1,980	-	-
"	"	"	1947	Lennox	9.9	43.4	52.4	4.2	2.2	-	-	-	-	11,990	13,310	2,000	-	-
"	"	Johnie's	1947		8.4	42.5	53.4	4.1	.5	5.4	76.5	1.7	11.8	12,380	13,490	2,310	-	-
"	"	Pinnacle	1949		8.6	41.7	50.0	8.8	.6	-	-	-	-	11,620	[illegible]	2,440	-	-
Routt	Routt	Keystone	1948	Pinnacle	6.9	40.7	52.9	6.4	0.6	-	-	-	-	12,320	13,230	2,550	-	-
"	"	"	1948	"	7.0	42.3	51.7	6.0	.5	-	-	-	-	12,290	13,210	2,320	-	-
"	"	"	1948	"	7.1	42.0	51.6	6.4	.6	-	-	-	-	12,240	13,180	2,570	-	-
"	"	"	1948	"	7.9	43.2	52.2	4.6	.6	5.3	75.6	1.7	12.2	12,350	13,410	2,420	-	-
"	"	"	1948	"	10.4	42.7	52.8	4.4	.5	-	-	-	-	12,180	13,420	2,050	-	-
"	"	"	1947	"	9.0	41.7	50.2	8.1	.6	-	-	-	-	11,710	12,870	2,750	-	-
"	"	"	1949	"	6.3	41.5	50.5	7.7	.6	-	-	-	-	12,060	12,900	-	-	-
Weld	Dacono	Boulder Valley No. 1	1948	Laramie	24.9	39.3	55.9	4.8	.5	4.7	72.8	1.6	15.5	9,300	12,510	2,080	-	-
"	"	"	1945	"	24.7	39.3	55.4	5.3	.6	-	-	-	-	9,400	12,450	2,210	-	-
"	"	"	1948	"	24.6	33.7	43.1	7.3	.7	-	-	-	-	[illegible]	12,290	[illegible]	-	-
"	"	"	1948	"	22.6	35.8	54.2	[illegible]	.6	-	-	-	-	9,130	12,[illegible]	[illegible]	-	-
"	"	"	1949	"	22.0	35.7	54.0	[illegible]	[illegible]	-	-	-	-	9,590	12,370	2,000	-	-
"	"	"	1950	"	25.1	37.7	[illegible]	5.2	.5	-	-	-	-	9,300	12,400	2,130	-	-
"	"	"	1948	"	24.7	39.1	52.2	8.7	.8	-	-	-	-	9,060	12,040	1,970	-	-

Table B-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Beds	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Colorado (continued)													
Weld	Dacono	Boulder Valley No. 3	1946	Laramie	[illegible]	[illegible]	[illegible]	7.5	.3	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	23.0	35.4	[illegible]	5.4	.5	-	-	-	-	9,490	12,330	2,030	-	-
"	Erie	Eagle	1947		[illegible]	[illegible]	[illegible]	4.7	.4	6.2	[illegible]	1.2	26.4	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1947		[illegible]	[illegible]	[illegible]	[illegible]	.3	-	-	-	-	9,852	[illegible]	[illegible]	-	-
"	"	"	1947		[illegible]	41.0	[illegible]	[illegible]	.3	-	-	-	-	9,810	12,660	2,050	-	-
"	"	"	1947		[illegible]	[illegible]	[illegible]	7.6	.4	-	-	-	-	9,560	[illegible]	[illegible]	-	-
"	"	"	1949		[illegible]	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	[illegible]	2,060	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.4	-	-	-	-	[illegible]	12,330	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	9,710	[illegible]	[illegible]	-	-
"	"	Imperial	1947		23.3	39.2	[illegible]	4.0	.4	-	-	-	-	9,660	12,580	2,140	-	-
"	"	"	1947		[illegible]	40.2	[illegible]	6.0	.3	-	-	-	-	9,670	[illegible]	2,180	-	-
"	"	"	1947		[illegible]	40.3	51.1	6.6	.4	-	-	-	-	9,690	12,500	2,080	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.4	6.3	[illegible]	1.3	16.4	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1949		[illegible]	41.8	[illegible]	4.8	.3	-	-	-	-	9,880	12,500	2,090	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.4	-	-	-	-	9,775	[illegible]	-	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.6	-	-	-	-	9,650	12,440	[illegible]	-	-
"	"	"	[illegible]		[illegible]	37.4	[illegible]	[illegible]	.5	-	-	-	-	9,660	12,440	2,040	-	-
"	"	"	[illegible]		[illegible]	39.0	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	[illegible]	2,010	-	-
"	"	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.6	6.7	[illegible]	1.5	26.9	9,380	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.3	-	-	-	-	9,460	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.6	-	-	-	-	9,540	[illegible]	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.4	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.3	-	-	-	-	10,480	[illegible]	-	-	-
"	"	"	[illegible]		[illegible]	39.5	[illegible]	6.6	.4	-	-	-	-	9,820	[illegible]	[illegible]	-	-
"	"	"	1949		[illegible]	[illegible]	56.6	5.9	.5	-	-	-	-	9,900	12,380	[illegible]	-	-
"	"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.4	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-

Table C-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Bed	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, %: Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
Weld	Frederick	[illegible]	1965		[illegible]	33.1	[illegible]	[illegible]	.4	-	-	-	-	9,[illegible]	12,[illegible]	-	-	-
Delta	Grand Mesa	Green Valley	1958	Green Valley	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	11,[illegible]	12,[illegible]	2,330	-	59
"	"	Red Canon	1955	No. 5	11.8	38.7	49.4	6.9	.7	5.2	71.2	1.8	13.2	11,190	12,690	2,380	-	49
"	"	Tomahawk	1953	A	11.7	40.5	42.5	8.2	1.2	[illegible]	71.2	1.5	12.8	10,960	12,700	2,810	-	53
"	"	Top	1959	No. [illegible]	14.5	41.3	53.0	5.1	.6	-	-	-	-	11,240	13,140	2,570	-	56
"	Somerset	King	1964	B	4.5	41.2	52.5	6.3	.5	5.5	77.3	1.6	10.4	13,[illegible]	13,[illegible]	2,360	-	57
"	"	Paonia	1954	B	5.9	41.7	53.7	4.6	.6	-	-	-	-	12,[illegible]	13,[illegible]	2,420	-	52
"		Farmer																
Garfield	Book Cliffs	Carbon-era	1934	Carbon-era	11.4	35.5	43.7	9.4	.6	-	-	-	-	11,150	12,570	2,850	-	-
"	"	Stove Canyon	1954	"	6.7	40.6	51.7	7.7	.7	-	-	-	-	12,380	13,270	-	-	-
"	Carbondale	[illegible]	1936	D	6.1	38.3	53.5	1.9	.5	5.8	72.2	1.7	18.1	13,170	14,030	-	-	-
"	"	Sun-light	1955	D	4.4	42.2	54.0	3.8	.9	5.5	78.1	1.9	13.5	13,010	13,600	2,650	-	48
"	Grand Hogback	Coryell	1939	Allen	4.1	38.2	52.7	5.0	.5	5.7	73.0	1.7	14.6	13,230	13,790	-	-	-
"	"	New Castle	1959	"	3.[illegible]	44.5	[illegible]	4.9	.6	5.5	76.9	1.8	10.1	13,120	13,660	2,280	-	-
"	"	S. Canon	1959	"	8.2	43.9	[illegible]	4.2	.4	5.4	76.9	2.0	12.9	12,310	13,420	2,280	-	-
"	"	Vulcan	1941	"	7.1	40.8	46.9	5.2	.5	5.1	73.8	1.6	14.4	12,620	13,590	2,370	-	-
Gunnison	Crested Butte	Alpine	1933		11.3	41.4	52.9	6.7	.3	5.6	67.[illegible]	1.2	[illegible]	[illegible]	13,[illegible]	2,190	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								COLORADO (continued)										
Gunnison	Crested Butte	Bulkley	[illegible]	No. 4	3.5	33.7	52.1	4.7	.4	5.3	82.1	1.1	13.1	12,760	13,[illegible]	-	-	-
"	"	Crested Butte	[illegible]	Crested Butte	1.7	35.7	[illegible]	5.2	.4	5.4	75.8	1.6	12.7	13,530	13,970	2,750	-	-
"	"	Floresta	1911	Ruby	1.7	4.9	85.5	16.1	.5	-	-	-	-	11,810	12,270	-	-	-
"	"	Horace	1954		3.9	6.2	83.6	10.2	.6	3.2	83.3	1.1	3.9	13,210	13,790	2,240	-	27
"	Somerset	Bear	1958	[illegible]	6.3	36.6	53.5	8.3	.5	5.5	75.1	1.7	10.5	12,170	13,070	2,570	-	46
"	"	Hawk's Nest	1957	[illegible]	6.1	[illegible]	[illegible]	3.7	.5	5.5	79.2	1.7	9.5	13,[illegible]	13,990	2,140	-	51
"	"	Oliver	1955	B	5.3	40.4	54.6	[illegible]	.6	5.2	69.3	1.4	11.1	12,690	13,630	2,510	-	52
"	"	Somerset	1952	"	5.7	39.5	51.6	8.9	.4	5.3	69.7	1.4	14.5	12,440	13,[illegible]	2,420	-	46
Mesa	Book Cliffs	Book Cliffs	1911	Cameo	7.5	38.4	43.4	10.7	.6	5.5	61.8	1.1	21.0	11,780	12,740	-	-	-
"	"	Cameo	1960	"	8.2	34.7	45.2	11.8	.6	5.5	65.5	1.2	16.5	11,090	12,440	2,310	-	50
"	"	Garfield	[illegible]	Palisade	14.2	31.1	45.7	6.0	.6	5.8	62.2	1.4	24.0	10,960	12,620	-	-	-
"	"	Palisade	[illegible]	"	7.5	36.0	50.5	6.0	.9	5.9	68.4	1.6	17.8	12,310	13,310	-	-	-
Moffat	Danforth Hill	Red Wing	1953	[illegible]	11.2	43.2	[illegible]	[illegible]	.8	-	-	-	-	11,820	13,310	2,430	-	51
"	"	Streeter	1973	"	10.4	35.5	45.4	3.5	.2	5.4	66.3	1.7	23.4	11,830	13,230	-	-	-
Pitkin	Carbondale	Coal Basin	1958	Sunshine	3.1	23.4	67.1	[illegible]	.5	4.7	79.6	1.8	4.8	13,980	14,430	-	-	-
"	"	Dutch Creek	1959	B	4.9	23.0	68.0	8.4	.6	4.8	81.9	2.0	[illegible]	13,780	14,480	2,250	-	110
"	"	Spring	[illegible]	Anderson	5.4	34.0	55.4	7.2	.8	5.4	74.5	1.6	10.7	11,500	13,080	-	-	-
"	"	Thompson	1961	"	5.1	[illegible]	57.5	7.5	.6	4.9	72.8	1.9	3.1	13,[illegible]	14,230	[illegible]	-	[illegible]

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu MAF	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
Rio Blanco	Danforth Hill	Blue Streak	[illegible]		12.4	47.4	53.6	5.6	.6	5.1	73.1	1.3	12.7	11,290	12,900	2,720	-	59
"	"	Rienau	1968	[illegible]	13.8	41.3	54.3	4.7	.5	-	-	-	-	11,390	13,210	2,540	-	57
"	Lower White River	White River	[illegible]	"	11.7	37.7	53.8	8.5	.5	5.0	72.3	1.5	14.2	10,990	12,370	2,900	-	55
Gunnison	Coal Creek	Coredrill			2.4	40.4	53.5	3.7	1.0	5.7	77.8	1.6	10.2	14,040	-	-	-	-
"	"	"			2.4	39.9	52.3	5.4	.5	5.6	76.9	1.5	10.1	14,050	-	-	-	-
"	"	"			2.1	38.4	57.4	7.1	.5	5.5	75.7	1.5	9.7	14,790	-	-	-	-
"	"	Oliver No. 10		No. 10	4.1	39.8	50.5	5.2	.5	-	-	-	-	14,260	-	-	-	-
"	"	Hawk's Nest		No. 13	5.7	35.2	57.7	3.4	.6	-	-	-	-	13,750	-	-	-	-
"	Paonia Coalfield	Coredrill			10.2	40.0	46.1	3.5	.5	5.9	69.2	1.5	20.4	12,500	-	-	-	-
"	"	"			10.8	38.6	46.2	6.4	.6	5.7	65.2	1.5	20.7	13,320	-	-	-	-
"	"	"			10.3	39.2	46.2	4.3	.4	5.9	67.7	1.4	20.3	12,540	-	-	-	-
"	"	"			10.7	38.8	46.7	4.3	.7	6.1	67.2	1.5	19.7	12,680	-	-	-	-
"	"	"			9.6	37.1	42.0	12.3	.6	5.5	62.1	1.4	18.1	12,930	-	-	-	-
"	"	"			9.6	43.6	40.8	9.0	1.7	5.8	64.0	1.3	18.2	12,760	-	-	-	-
"	"	"			9.4	37.5	41.7	9.4	.5	5.7	79.4	1.5	17.5	12,230	-	-	-	-
"	"	"			7.2	37.4	47.3	13.1	.5	5.5	62.7	1.5	16.3	13,350	-	-	-	-
"	"	"		Somerset	7.3	35.5	43.2	9.4	.5	5.8	69.6	1.5	15.3	11,960	-	-	-	-
"	"	"		"	7.0	39.0	52.8	5.5	.7	5.6	76.8	1.7	10.5	13,020	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
COLORADO (continued)																		
Las Animas		Frederick		Frederick Raton	[illegible]	29.7	[illegible]	[illegible]	.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
Pitkin		Dutch Creek		Coal Basin	[illegible]	22.6	[illegible]	7.4	.6	5.1	75.2	1.7	6.8	14,960	-	-	-	-
Weld		Puritan		Unknown	19.7	29.4	46.4	4.5	.4	[illegible]	58.1	[illegible]	29.5	10,580	-	-	-	-
Delta	Grand Mesa	King			3.1	41.6	52.3	[illegible]	.5	-	-	-	-	13,150	[illegible]	[illegible]	-	-
"	Bowie	"			[illegible]	41.4	[illegible]	[illegible]	.5	-	-	-	-	13,320	13,710	2,840	-	-
Fremont	Canon City	Corley No. 2			9.5	42.6	[illegible]	7.5	.5	-	-	-	-	11,530	13,750	-	-	-
"	"	Pioneer			10.9	38.5	[illegible]	8.6	.4	-	-	-	-	11,050	12,410	-	-	-
"	Florence	Vento			[illegible]	37.2	[illegible]	[illegible]	.4	-	-	-	-	11,800	12,150	2,260	-	-
Gunnison	Crested Butte	Bear			6.3	40.0	[illegible]	6.7	.6	5.1	75.7	1.8	9.9	12,680	13,530	2,680	2 1/2	54
"	Somerset	Edwards			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	12,560	[illegible]	2,670	-	-
Pitkin	Carbondale	Thompson Creek No. 2			3.5	30.3	[illegible]	14.1	1.2	[illegible]	[illegible]	[illegible]	[illegible]	12,850	[illegible]	2,870	8	83
"	"	Thompson Creek No. 3			5.1	29.5	48.2	[illegible]	1.1	-	-	-	-	[illegible]	11,640	2,470	8	86
"	"	Thompson Creek No. 1			[illegible]	34.9	[illegible]	7.6	.6	-	-	-	-	13,800	14,230	2,620	[illegible]	[illegible]
Weld	Walsenburg	Eagle			[illegible]	35.5	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

Source	Coal field or town	Mine: Name	Mine: Type of mine	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Proximate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Utah (continued)													
Wells	Boulder Well	[illegible]			[illegible]	47.[illegible]	[illegible]	6.7	.4	-	-	-	-	9,[illegible]	12,4[illegible]	-	-	-
"	"	"			10.2	37.9	54.2	7.9	.4	-	-	-	-	9,460	12,250	2,170	-	-
"	Erie	Imperial			21.5	37.4	56.1	5.3	.2	-	-	-	-	9,860	12,610	-	-	-
"	"	"			19.0	35.1	54.9	[illegible]	.4	-	-	-	-	10,[illegible]	12,380	-	-	-
Prewett	Florence	Bear Creek No. 2			9.1	40.2	50.1	9.7	1.8	-	-	-	-	11,600	12,650	2,050	-	-
"	"	"			9.8	33.7	53.5	5.9	1.3	-	-	-	-	11,410	12,640	2,050	-	-
"	"	"			7.8	37.8	40.2	14.4	1.4	-	-	-	-	10,520	11,[illegible]	[illegible]	-	45
"	"	Canon Monarch No. 4			12.4	37.5	50.7	6.8	.7	-	-	-	-	11,140	12,720	2,470	-	-
"	"	"			12.4	39.0	54.1	[illegible]	.7	-	-	-	-	11,120	12,7[illegible]	2,[illegible]	-	-
"	"	"			12.7	40.4	52.7	11.6	.8	-	-	-	-	10,7[illegible]	11,7[illegible]	2,280	-	47
"	"	Curley Stirk			11.2	37.4	40.8	11.8	.5	-	-	-	-	[illegible]	[illegible]	2,040	-	-
"	"	Double Dike			11.0	37.4	51.0	10.0	.4	-	-	-	-	10,730	12,050	2,360	-	-
"	"	"			13.1	34.7	45.9	19.6	.5	-	-	-	-	9,640	10,750	2,450	-	42
"	"	Pioneer Canon			[illegible]	38.1	52.0	9.3	.9	-	-	-	-	11,[illegible]	12,[illegible]	-	-	-
Sunnyside	Somerset	Rome's Seat			[illegible]	[illegible]	[illegible]	3.9	.4	-	-	-	-	11,[illegible]	14,[illegible]	2,[illegible]	-	-
"	"	"			5.4	[illegible]	[illegible]	5.4	.4	[illegible]	79.[illegible]	1.[illegible]	[illegible]	13,460	[illegible]	2,[illegible]	-	53
"	"	"			[illegible]	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	13,390	14,100	2,180	-	-
"	"	"			[illegible]	[illegible]	[illegible]	3.7	.5	-	-	-	-	13,[illegible]	13,[illegible]	2,170	-	-
[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,[illegible]	12,440	2,[illegible]	-	-
"	"	"			[illegible]	[illegible]	53.8	[illegible]	.5	-	-	-	-	11,[illegible]	12,[illegible]	2,[illegible]	-	-
"	"	"			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	10,[illegible]	12,[illegible]	2,[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Type of mining	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
								COLORADO (continued)										
Routt	Oak Creek	Edna			7.7	41.7	48.4	5.4	.6	-	-	-	-	11,5[illegible]	12,4[illegible]	2,190	-	-
Delta	Bowie	King		Uncorre-lated	4.1	47.2	53.5	4.4	.5	5.3	78.2	1.8	9.9	13,4[illegible]	14,0[illegible]	2,5[illegible]	-	-
"	"	"		"	4.6	41.1	52.7	6.2	.6	-	-	-	-	13,080	13,710	2,810	4 1/2	48
Fremont	Florence	Pioneer Canon Prep. Plant		"	9.7	38.6	52.1	9.3	.4	-	-	-	-	11,0[illegible]	12,200	-	-	-
"	"	"		"	10.5	37.4	50.1	12.5	.4	-	-	-	-	10,540	11,790	2,190	-	-
"	"	Vento		"	10.5	37.1	50.3	12.1	[illegible]	-	-	-	-	10,650	11,900	2,240	-	-
Gunnison	Somerset	Bear		Juanita C	5.9	41.8	55.4	2.8	.5	-	-	-	-	13,160	13,980	2,490	-	-
"	"	"		"	6.1	39.9	52.9	7.2	.6	-	-	-	-	12,510	13,320	2,570	-	-
"	"	"		"	5.5	40.1	52.6	7.1	.5	-	-	-	-	12,610	13,340	2,650	-	-
"	"	"		"	7.8	39.9	52.6	7.5	.6	-	-	-	-	12,210	13,240	2,620	2 1/2	51
Mesa	Palisade	Roadside		Cameo	6.1	35.1	51.8	13.1	.6	-	-	-	-	11,870	12,7[illegible]	2,5[illegible]	2	53
Routt	Oak Creek	Edna		Wadge	6.7	41.4	49.0	9.6	.2	-	-	-	-	11,260	12,310	2,890	-	-
"	"	"		"	8.9	40.9	49.0	10.1	.2	-	-	-	-	11,150	12,230	2,910	-	-
"	"	Energy		"	10.1	41.1	50.7	8.6	.5	-	-	-	-	11,380	12,660	2,600	-	46
Weld	Erie	Eagle		Uncorre-lated	21.[illegible]	39.1	55.7	5.2	.3	-	-	-	-	9,9[illegible]	12,6[illegible]	-	-	-
"	"	"		"	22.1	35.8	55.1	6.2	.3	-	-	-	-	9,71[illegible]	12,4[illegible]	2,08[illegible]	-	-
"	"	Imperial		"	21.3	38.6	56.1	4.9	.3	-	-	-	-	9,870	12,5[illegible]	-	-	-
"	"	"		"	22.7	38.6	54.8	6.[illegible]	[illegible]	-	-	-	-	9,580	12,350	2,0[illegible]	-	-
Mesa	Palisade	Roadside		Cameo	[illegible]	37.[illegible]	48.[illegible]	11.[illegible]	.[illegible]	-	-	-	-	11,[illegible]	12,[illegible]	2,3[illegible]	[illegible]	5[illegible]
"	"	"		"	9.[illegible]	39.[illegible]	51.[illegible]	9.[illegible]	.[illegible]	5.[illegible]	73.[illegible]	1.5	10.[illegible]	11,[illegible]	12,[illegible]	2,[illegible]	-	-
"	"	"		"	9.4	35.1	47.[illegible]	14.[illegible]	.[illegible]	-	-	-	-	11,[illegible]	12,[illegible]	2,[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal Field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
								COLORADO (continued)										
Moffat	Craig	Wise Hill No. 1			16.0	39.4	54.8	5.8	.5	5.1	72.8	1.5	14.3	10,630	12,660	2,260	-	-
Fremont	Florence	Canon Monarch No. 4			12.7	36.0	51.0	13.0	.8	4.7	69.9	1.2	11.6	10,180	11,660	2,310	-	46
Weld	Erie	Eagle			20.7	38.4	56.1	5.5	.8	-	-	-	-	9,970	12,580	-	-	-
"	"	"			22.6	38.2	55.3	6.5	.4	-	-	-	-	9,620	12,440	2,340	-	-
"	"	Imperial			21.7	38.3	55.9	5.8	.3	-	-	-	-	9,860	12,600	-	-	-
"	"	"			21.7	38.5	54.9	6.6	.3	-	-	-	-	9,710	12,410	1,990	-	-
"	"	Washington			23.1	37.9	56.9	5.2	.3	-	-	-	-	9,710	12,620	2,040	-	-
"	"	"			23.9	37.7	56.8	5.5	.4	-	-	-	-	9,550	12,560	2,020	-	-
"	"	"			23.2	37.7	55.6	6.7	.5	-	-	-	-	9,510	12,380	2,020	-	-
"	"	"			24.5	37.7	56.1	6.2	.4	-	-	-	-	9,400	12,450	2,020	-	48
"	"	"			24.1	37.3	56.1	6.6	.5	-	-	-	-	9,410	12,390	2,020	-	-
"	"	"			24.4	37.2	56.1	6.7	.4	-	-	-	-	9,320	12,320	2,020	-	-
Montezuma		Todd			11.0	40.3	42.2	6.5	0.8	-	-	-	-	11,630	-	-	-	-
"		"			13.1	39.6	39.2	7.6	.7	-	-	-	-	11,150	-	-	-	-
"		"			12.1	39.7	41.2	7.0	.7	5.3	61.4	1.4	21.6	11,360	-	-	-	-
"		"			12.1	37.7	44.1	6.1	.6	5.3	64.4	1.4	21.5	11,190	-	-	-	-
"		Jackson			12.2	41.3	40.4	6.1	0.8	-	-	-	-	11,380	-	-	-	-
"		"			12.3	42.2	40.5	5.0	.8	-	-	-	-	11,520	-	-	-	-
"		"			13.8	40.7	39.9	5.6	.5	-	-	-	-	[illegible]	-	-	-	-
"		"			12.8	41.3	40.2	5.7	.5	5.1	[illegible]	1.3	23.9	11,380	-	-	-	-
"		"			-	47.6	46.1	6.3	.7	5.4	72.8	1.6	13.2	13,030	-	-	-	-
"		"			-	52.7	47.3	-	.6	5.7	77.8	1.7	14.2	[illegible]	-	-	-	-
"		[illegible]			12.0	39.0	41.7	7.3	.6	5.5	[illegible]	1.4	[illegible]	11,400	-	-	-	-
"		"			-	43.8	48.4	7.8	.7	5.7	72.4	1.6	11.8	12,990	-	-	-	-
"		"			-	48.5	51.5	-	.7	6.2	78.6	1.7	12.8	14,090	-	-	-	-

Table 8-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Proximate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
MONTANA[1],[2]																		
Big Horn	13 mi SE of Lodge-grass	Prospect	1967		[illegible]	[illegible]	51.1	7.7	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"		"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"		"	1967		[illegible]	[illegible]	[illegible]	13.4	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	15 mi SE of Lodge-grass	"	1967		24.6	41.6	[illegible]	14.8	[illegible]	3.9	56.9	0.9	21.5	[illegible]	[illegible]	-	-	-
"		"	1967		[illegible]	[illegible]	54.4	7.7	0.6	[illegible]	71.5	1.1	14.9	[illegible]	[illegible]	-	-	-
		Cow Gulch Prospect	1967		[illegible]	[illegible]	54.9	[illegible]	0.9	-	-	-	-	9,320	11,590	-	-	-
"	"	Prospect	1967		18.7	46.4	49.3	[illegible]	1.0	-	-	-	-	9,890	12,160	-	-	-
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1967		22.5	[illegible]	[illegible]	[illegible]	0.4	-	-	-	-	[illegible]	11,730	-	-	-
"	"		1967		24.2	41.2	52.1	5.7	0.5	5.8	[illegible]	1.3	16.7	[illegible]	11,790	-	-	-
		[illegible] Hendricks	1967		28.8	41.5	53.9	4.6	0.5	-	-	-	-	8,730	11,570	-	-	-
"	Decker	Tongue River	1967		[illegible]	[illegible]	53.7	[illegible]	0.9	-	-	-	-	[illegible]	[illegible]	[illegible]	-	52
[illegible]	[illegible] Lodge	[illegible]	1967		[illegible]	[illegible]	47.1	17.6	2.1	-	-	-	-	[illegible]	[illegible]	-	-	-
[illegible]	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	13.1	0.8	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	[illegible] Gulch	1967		[illegible]	[illegible]	[illegible]	[illegible]	0.9	-	-	-	-	7,600	9,810	-	-	-
"	[illegible]	No. 1	1967		[illegible]	[illegible]	[illegible]	[illegible]	0.8	4.2	[illegible]	1.4	[illegible]	7,810	[illegible]	-	-	-
"	Indian Res.		1967		11.9	37.6	[illegible]	14.5	0.7	2.5	58.6	1.0	22.5	-	-	-	-	-
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.5	[illegible]	[illegible]	11,140	-	-	-
"	[illegible]	[illegible]	1967		[illegible]	33.1	[illegible]	[illegible]	0.9	-	-	-	-	[illegible]	11,140	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
					MONTANA (continued)													
Blaine	Cleveland	Cook	1967		18.8	38.8	49.7	11.5	0.9	-	-	-	-	9,140	11,250	-	-	-
"	Ada	Gibbits	1967		16.0	33.5	52.6	13.8	1.4	4.5	65.4	1.4	13.5	9,563	11,550	-	-	-
"	Chinook	Rader	1967		23.1	34.6	52.7	12.7	0.7	-	-	-	-	8,570	11,500			
"	"	Rader Prospect	1967		21.4	35.6	53.0	11.4	0.7	4.4	61.1	1.6	15.8	8,940	11,370	-	-	-
"	"	Raeder	1967		21.0	36.4	50.5	13.1	0.8	4.3	65.7	1.5	14.6	8,780	11,100	-	-	-
"	E Harlem	Government	1967		23.8	38.1	47.2	14.7	0.9	4.2	59.2	1.9	19.1	7,580	9,950	-	-	-
"	Chinook	Tumbler	1967		21.4	33.9	52.3	13.8	0.8	4.3	65.2	1.4	15.5	8,650	11,020	-	-	-
"	"	Kerr	1967		20.5	36.2	49.4	14.4	1.0	-	-	-	-	-	-	-	-	-
"	"	Milk River	1967		25.6	36.9	51.1	14.4	1.0	4.3	66.6	1.5	15.1	8,320	11,200	-	-	-
"	"	Milk River	1967		26.0	38.6	51.9	11.8	0.7	4.5	67.0	1.4	17.0	8,510	11,510	-	-	-
"	"	Sands & O'Keef	1967		22.9	37.3	51.0	9.5	0.6	-	-	-	-	8,433	10,968	-	-	-
"	"	Matherson Prospect	1967		23.3	38.9	43.2	17.9	0.9	4.2	58.5	1.2	17.1	7,798	10,163	-	-	-
"	Harlem	McDaniels	1967		30.0	57.3	25.7	17.0	1.5	3.1	57.7	1.1	19.6	6,910	9,880	-	-	-
"	Chinook	Lasso	1967		26.7	35.0	54.6	9.4	0.9	4.3	67.1	1.2	17.1	8,440	11,510	-	-	-
"	"	"	1967		23.6	35.0	48.7	16.3	0.7	3.8	59.7	1.3	18.1	7,673	10,044	-	-	-
Broadwater	1 mi W of Lombard	Hogg	1967		2.8	25.2	44.2	30.6	8.5	-	-	-	-	10,000	10,350	-	-	-
"	"	"	1967		3.7	26.7	54.0	19.3	7.3	-	-	-	-	-	-	-	-	-
"	"	"	1967		3.0	20.3	40.7	39.0	7.2	2.9	45.5	0.5	4.2	8,105	8,357	-	-	-
"	"	Western	1967		3.0	24.8	50.1	24.5	8.3	-	-	-	-	10,570	10,890	-	-	-
"	"		1967		3.3	24.4	51.4	24.2	10.8	-	-	-	-	10,620	10,980	-	-	-
"	Lombard	Montana Bituminous	1967		3.2	20.7	41.1	38.2	7.4	3.0	45.6	0.5	2.4	8,670	8,960	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Year of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					MONTANA (continued)													
Carbon	[illegible] Joliet	Joliet	1967		8.4	-	-	-	-	-	-	-	-	-	-	-	-	-
"	Nye	[illegible] No. 2	1967		9.7	33.2	51.2	15.2	0.7	4.4	62.3	1.1	15.9	10,240	11,340	-	-	-
"	[illegible]	[illegible]	1967		8.3	-	-	-	-	-	-	-	-	-	-	-	-	-
"	"	"	1967		8.5	34.9	48.7	16.8	0.7	4.4	64.4	1.2	12.5	10,478	11,452	-	-	-
"	Bridger	Bridger	1967		14.8	-	-	-	-	-	-	-	-	10,037	-	-	-	-
"	"	"	1967		8.6	34.4	45.7	19.9	0.9	-	-	-	-	-	-	-	-	-
"	"	"	1967		9.6	37.9	51.3	16.8	0.5	-	-	-	-	-	-	-	-	-
"	"	"	1967		8.7	-	-	-	-	-	-	-	-	-	-	-	-	-
"	Nye	"	1967		14.8	31.6	52.7	15.7	0.9	4.6	67.0	1.1	11.2	10,090	11,790	-	-	-
"	Bridger	"	1967		8.5	35.4	49.9	14.7	0.6	4.5	66.0	1.2	12.1	11,665	11,686	-	-	-
"	Red Lodge	NW Improvement	1967		....	-	-	-	-	-	-	-	-	9,787	-	-	-	-
"	"	"	1962		14.1	-	-	-	-	-	-	-	-	-	-	-	-	-
"	"		1967		11.3	-	-	-	-	-	-	-	-	-	-	-	-	-
"	"	NW Improvement	1967		11.1	-	-	-	-	-	-	-	-	-	-	-	-	-
"	"	"	1967		11.3	-	-	-	-	-	-	-	-	-	-	-	-	-
"	"	"	1967		10.6	-	-	-	-	-	-	-	-	-	-	-	-	-
"	"	"	1967		10.6	-	-	-	-	-	-	-	-	-	-	-	-	-
"	"	Red-Lodge No. 1	1967		11.1	43.0	47.0	-	0.9	-	-	-	-	10,440	11,300	-	-	-
"	"	Red-Lodge No. 4	1967		11.1	-	-	-	-	-	-	-	-	10,463	-	-	-	-
"	"	"	1963		12.1	-	-	-	-	-	-	-	-	10,1[illegible]	-	-	-	-
"	"	"	1963		9.9	-	-	-	-	-	-	-	-	[illegible]	-	-	-	-
"	"	"	1967		10.8	35.1	45.4	13.5	1.1	4.5	61.9	1.3	13.1	10,860	11,936	-	-	-
"	"	"	1967		10.2	35.2	49.8	11.9	1.1	5.0	67.6	1.2	12.9	10,710	11,[illegible]	-	-	-
"	"	"	1967		9.5	35.5	47.9	16.6	2.9	4.5	62.6	1.4	12.6	10,160	11,[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Carbon	Bearcreek	Red Lodge	1967		10.4	37.7	39.8	12.5	2.5	-	-	-	-	10,590	[illegible]	-	-	-
"	1/4 mi SW Bearcreek	No. 4 Interna-tional	1967		11.1	-	-	-	-	-	-	-	-	10,800	-	-	-	-
"	"	"	1967		12.5	-	-	-	-	-	-	-	-	10,660	-	-	-	-
"	"	"	1967		11.7	38.6	51.9	9.5	1.9	4.8	68.6	1.9	13.3	10,760	12,190	-	-	-
"	"	"	1967		9.3	37.6	50.6	11.8	2.2	4.6	65.6	1.5	14.3	10,470	11,550	-	-	-
"	"	"	1967		11.7	38.3	50.6	11.1	2.0	4.8	67.7	1.9	12.5	10,510	11,910	-	-	-
"	Red Lodge	[illegible]	1967		10.9	37.8	56.6	5.6	1.0	5.0	73.0	1.9	13.5	11,360	12,750	2,080	-	-
"	"	"	1967		11.1	39.2	51.5	9.3	1.6	-	-	-	-	10,820	12,170	-	-	-
"	"	"	1967		9.3	-	-	-	-	-	-	-	-	11,190	-	-	-	-
"	"	"	1967		10.5	-	-	-	-	-	-	-	-	10,930	12,220	-	-	-
"	"	"	1967		10.5	-	-	-	-	-	-	-	-	10,920	-	-	-	-
"	"	"	1967		11.8	42.6	50.4	7.0	2.1	-	-	-	-	11,010	12,480	-	-	-
"	"	"	1967		10.4	-	-	-	-	-	-	-	-	10,240	-	-	-	-
"	"	"	1967		11.5	40.0	53.4	6.6	1.4	-	-	-	-	11,220	12,680	-	-	-
"	"	"	1967		11.2	38.7	52.5	8.8	1.2	-	-	-	-	10,870	12,240	-	-	-
"	"	"(deep)	1967		10.9	37.8	56.6	5.6	1.0	5.0	73.0	1.9	13.5	11,360	12,750	-	-	-
"	"	"	1967		9.3	38.5	53.6	7.9	1.5	-	-	-	-	11,190	12,340	-	-	-
"	"	"	1967		10.5	37.6	52.8	9.6	1.8	-	-	-	-	10,910	12,200	-	-	-
"	"	Brophy	1967		10.9	37.6	52.8	9.6	1.3	4.7	69.8	1.7	12.9	10,840	12,160	-	-	-
"	2 mi W of Bearcreek	[illegible] No. 1	1967		8.9	35.3	50.1	11.6	3.2	4.9	65.3	1.4	13.6	10,604	11,615	-	-	-
"	Washoe	Washoe	1967		10.5	-	-	-	-	-	-	-	-	10,840	-	-	-	-
"	"	"	1967		11.0	-	-	-	-	-	-	-	-	10,480	-	-	-	-
"	"	"	1967		10.4	-	-	-	-	-	-	-	-	10,280	-	-	-	-
"	"	"	1967		10.8	-	-	-	-	-	-	-	-	10,750	-	-	-	-
"	"	"	1967		10.5	35.7	45.8	12.5	1.3	4.9	66.8	1.4	12.1	[illegible]	11,760	-	-	-
"	"	Roadside	1967		8.9	37.6	48.9	13.5	4.3	4.3	65.5	1.6	10.8	10,470	11,490	-	-	-

Table I-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

MONTANA (continued)

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
MONTANA (continued)																		
Carbon	1.5 mi W of Bearcreek	No. 2	1967		10.7	-	-	-	-	-	-	-	-	10,710	-	-	-	-
"	"	"	1967		11.1	-	-	-	-	-	-	-	-	10,820	-	-	-	-
"	"	"	1967		10.8	-	-	-	-	-	-	-	-	10,550	-	-	-	-
"	"	"	1967		10.7	35.2	51.6	10.2	1.7	4.9	68.1	1.8	13.4	10,800	12,080	-	-	-
"	Bearcreek	Sew	1967		10.5	39.4	50.1	10.3	2.0	-	-	-	-	-	-	-	-	-
"	1.5 mi W of Bearcreek	No. 2	1967		9.9	35.9	48.6	12.4	1.9	-	-	-	-	10,615	11,780	-	-	-
"	Washoe	Foster	1967		9.2	-	-	-	-	-	-	-	-	11,[illegible]	12,200	-	-	-
"	1.5 mi E of Foster Mine		1967		9.0	39.7	47.4	12.9	3.3	-	-	-	-	-	-	-	-	-
"	1.5 mi E of Bearcreek	Nelson	1967		9.6	40.8	52.1	7.1	2.6	-	-	-	-	-	-	-	-	-
Carter	SW Camp Crook S.D.	[illegible]	1967		41.1	42.0	45.8	12.2	1.1	-	-	-	-	6,190	10,550	-	-	-
"	"	Kerr	1967		39.0	37.1	39.2	23.7	2.6	-	-	-	-	5,600	9,190	-	-	-
Cascade	Eden	Carville	1967		4.5	28.8	50.2	21.0	4.3	3.9	61.7	0.9	8.4	10,477	10,971	-	-	-
"	Great Falls	Deep Creek	1967		5.9	34.8	52.5	12.7	4.3	4.5	68.4	0.9	9.2	11,472	12,180	-	-	-
"	Eden	Patterson	1967		6.2	28.8	55.5	15.7	4.7	4.0	65.7	1.0	8.9	10,940	11,990	-	-	-
"	"	[illegible]	1967		4.9	28.5	49.5	21.0	4.2	4.2	55.9	[illegible]	4.4	10,[illegible]	12,[illegible]	-	-	-
"	Sand Coulee	[illegible]	1967		[illegible]	[illegible]	55.8	14.9	2.5	4.2	67.3	1.0	10.2	11,[illegible]	11,[illegible]	-	-	-
"	Stockett	Cottonwood	1967		[illegible]	[illegible]	54.7	15.0	2.5	4.5	67.7	1.0	9.8	11,150	11,870	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Year of analysis	Seam	Proximate analysis: Moisture	Proximate analysis: Volatile matter	Proximate analysis: Fixed carbon	Proximate analysis: Ash	Sulfur	Ultimate analysis: Hydrogen	Ultimate analysis: Carbon	Ultimate analysis: Nitrogen	Ultimate analysis: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
							MONTANA (continued)											
[illegible]	[illegible]	[illegible]	1967		[illegible]	[illegible]	47.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7,740	[illegible]			
"	"	[illegible]	1967		7.8	27.4	53.1	19.5	1.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	"	1967		5.4	29.4	47.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	*	*	*	*	*
"	[illegible]	[illegible]	1967		8.8	27.4	52.4	20.2	1.4	[illegible]	[illegible]	[illegible]	7.5	10,880	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	21.1	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
[illegible]	[illegible]	[illegible]	1967		17.5	[illegible]	[illegible]	13.5	[illegible]	[illegible]	[illegible]	1.8	[illegible]	9,117	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		18.2	[illegible]	[illegible]	13.8	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	*	*	*	*	*	*	*	*	[illegible]	*	*	*	*

Table D-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Rank	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
							MONTANA (continued)											
Custer	[illegible]	Kruptz-felt	1967		34.1	35.4	45.4	15.[illegible]	1.[illegible]	-	-	-	-	9,38[illegible]	11,[illegible]	-	-	-
"	Miles City	Weaver	1967		29.5	34.7	48.0	12.3	1.0	-	-	-	-	7,720	10,950	-	-	-
"	5 mi S Miles City	Old Weaver	1967		29.1	35.7	43.1	21.2	0.8	1.1	56.6	0.8	17.3	6,660	9,400	-	-	-
"		Storm King	1967		31.9	40.0	53.1	6.9	0.4	-	-	-	-	7,080	11,296	-	-	-
"	Miles City	Outcrop	1967		35.5	41.5	44.8	13.7	0.6	-	-	-	-	6,361	9,866	-	-	-
"		Smith	1967		31.2	37.4	40.8	13.8	1.0	-	-	-	-	7,361	10,755	-	-	-
"	[illegible]		1967		10.0	41.6	47.5	10.7	2.0	-	-	-	-	10,830	12,060	-	-	-
"	1 mi S Miles City	Hedges	1967		29.2	36.9	50.1	13.0	1.1	-	-	-	-	7,670	10,830	-	-	-
"	5 mi S Miles City	Kircher	1967		29.6	35.9	46.8	14.3	1.2	-	-	-	-	7,460	10,67[illegible]	-	-	-
"	Miles City	Kircher	1967		30.1	43.7	45.0	11.4	0.9	-	-	-	-	-	-	-	-	-
"	25 mi SW Miles City		1967		35.2	40.2	55.1	4.7	0.5	-	-	-	-	-	-	-	-	-
"	35 mi SW Miles City		1967		31.3	38.7	51.3	10.0	0.7	-	-	-	-	-	-	-	-	-
Daniels	Scobey	[illegible]	[illegible]		33.[illegible]	37.8	49.[illegible]	13.[illegible]	[illegible]	3.9	[illegible]	[illegible]	15.3	[illegible]	10,[illegible]	-	-	-
"	"	[illegible]	[illegible]		34.1	37.[illegible]	48.6	13.8	[illegible]	3.7	53.[illegible]	0.9	17.[illegible]	[illegible]	10,400	-	-	

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Year of sample	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Proximate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Daniels	E. Scobey	[illegible]	196-		42.8	35.2	45.0	15.7	5.0	-	-	-	-	5,671	9,820	-	-	-
Dawson	Glendive	Outcrop	1967		28.6	41.9	46.7	9.1	0.4	-	-	-	-	-	-	-	-	-
"	"	[illegible]	1967		25.8	40.9	46.2	13.0	2.9	3.9	63.8	1.1	25.1	6,730	11,640	-	-	-
"	"	[illegible]	1967		[illegible]	41.5	49.4	8.6	1.3	-	-	-	-	-	-	-	-	-
"	"	"	1967		34.8	38.0	35.0	11.0	1.7	4.2	58.8	2.9	17.3	7,000	10,835	-	-	-
"	"	"	1967		33.6	[illegible]	44.9	10.4	1.2	3.6	62.8	0.8	23.1	6,690	10,087	-	-	-
"	"	"	1967		34.9	[illegible]	[illegible]	12.4	2.2	[illegible]	[illegible]	[illegible]	[illegible]	6,904	[illegible]	-	-	-
"	"	"	1967		32.3	[illegible]	[illegible]	[illegible]	1.2	[illegible]	63.4	0.8	22.6	7,337	10,874	-	-	-
"	"	"	1967		33.2	[illegible]	42.1	12.4	1.5	-	-	-	-	-	-	-	-	-
"	"	"	1967		[illegible]	[illegible]	31.2	9.4	1.0	-	-	-	-	7,776	11,616	-	-	-
"	"	"	1967		32.1	37.7	50.4	11.9	2.0	-	-	-	-	7,110	10,470	-	-	-
"	"	[illegible]	1967		[illegible]	37.3	[illegible]	10.5	1.9	4.2	78.6	1.0	15.7	7,380	10,950	-	-	-
"	[illegible] Lignite	"	1967		33.5	-	-	-	-	-	-	-	-	6,800	-	-	-	-
"	[illegible]	[illegible]	1967		35.1	39.5	48.7	11.8	0.6	4.1	65.5	1.2	17.2	[illegible]	[illegible]	-	-	-
"	"	[illegible]	1967		36.1	41.5	46.9	11.6	0.9	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	Chimney Rock	1967		33.7	42.1	48.7	10.2	0.7	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	[illegible]	1967		33.7	39.1	53.7	8.2	0.5	-	-	-	-	[illegible]	[illegible]	-	-	-
Fallon		[illegible] Spring Prospect	1967		35.7	44.1	40.9	15.0	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	[illegible]	[illegible]	1967		41.3	[illegible]	45.7	15.3	1.0	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	[illegible]	1967		[illegible]	37.1	[illegible]	23.7	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal Field or town	Mine		Seam	Proximate analysis, %					Ultimate analysis, %				Btu as received	Btu dry	Ash softening tempera- ture, °F	Free swelling Index	Hardgrove grindability Index
		Name	Date of analy- sis		Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
								MONTANA (continued)										
Fergus	Lewistown	Rock	1967		9.2	35.3	45.7	15.6	10.1	-	-	-	-	9,670	10,650	-	-	-
"	Maury	Hand	1967		13.9	15.5	48.6	20.9	7.0	-	-	-	-	9,690	11,250	-	-	-
"	Moore	Cooper	1967		16.0	35.4	54.8	8.8	3.6	4.5	70.1	0.8	12.2	10,315	12,400	-	-	-
"	Rock Creek	Sharp	1967		15.7	35.2	51.8	12.9	3.3	-	-	-	-	-	-	-	-	-
"	Forest Grove	Hudson	1967		11.4	33.6	52.5	13.9	4.1	4.2	66.5	0.9	9.4	11,514	12,950	-	-	-
"	Lewistown	Pelger	1967		15.9	31.0	59.6	9.4	3.4	3.8	70.7	0.8	11.9	9,750	12,030	-	-	-
"	Winifred	Hughes	1967		11.5	29.1	52.4	18.5	5.1	3.7	65.1	0.8	11.7	9,270	11,890	-	-	-
"	"	Ammon	1967		9.1	32.6	50.6	16.8	4.4	4.1	64.2	0.9	9.8	10,215	11,257	-	-	-
"	Lewistown	Spring Cr.	1967		15.5	33.4	56.8	9.8	5.6	4.4	72.2	0.8	7.4	10,025	12,640	-	-	-
"	"	Sharp	1967		12.3	32.7	58.5	9.1	4.4	-	-	-	-	11,150	12,720	-	-	-
"	"	Hamilton	1967		12.7	33.3	55.3	10.2	4.2	-	-	-	-	10,930	12,490	-	-	-
"	"	Black Diamond	1967		14.1	31.9	56.4	11.7	4.3	4.1	63.7	0.9	9.1	10,409	12,150	-	-	-
"	Giltedge	Cliffs	1967		8.1	25.9	65.9	12.7	4.8	4.3	70.5	0.8	9.4	11,610	12,590	-	-	-
"	"	Gold Reef	1967		8.3	33.6	58.5	8.9	4.5	4.6	73.8	0.8	5.9	11,770	12,840	-	-	-
"	Lewistown	Flaherty	1967		9.8	31.6	46.9	21.4	5.1	-	-	-	-	9,013	10,990	-	-	-
"	"	Truax	1967		12.2	37.5	54.1	8.4	4.5	4.8	73.8	0.9	7.4	11,862	13,940	-	-	-
"	"	"	1967		11.8	37.8	51.6	11.2	3.6	4.7	69.6	0.8	10.8	11,170	12,570	-	-	-
"	Forest Grove	Ben Hill	1967		18.0	30.7	58.6	10.4	4.8	-	-	-	-	9,925	12,170	-	-	-

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Proximate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Fergus	Lewistown	Smith	1967		6.9	30.7	45.2	23.3	5.3	-	-	-	-	9,412	10,110	-	-	-
"	"	Mews & Farrar	1967		12.6	30.6	49.7	19.7	4.2	3.9	62.7	0.9	8.7	7,896	10,750	-	-	-
"	Gilt Edge	Sherman	1967		15.6	32.1	58.9	9.0	2.2	4.8	67.2	0.8	16.7	9,585	11,317	-	-	-
"	"	Shirley	1967		7.4	28.4	59.9	11.7	2.8	-	-	-	-	10,063	11,731	-	-	-
"	Maiden	Barr	1967		2.8	28.2	55.5	16.3	5.2	-	-	-	-	11,732	12,064	-	-	-
"	Hilger	Stone	1967		23.1	43.5	39.8	16.7	1.4	-	-	-	-	7,750	10,080	-	-	-
"	Winifred	Trask	1967		24.9	40.4	43.4	16.2	0.5	-	-	-	-	7,910	10,520	-	-	-
"	"	Outcrop	1967		27.6	39.6	41.6	18.8	3.7	-	-	-	-	6,611	9,151	-	-	-
"	"	Prospect	1967		24.8	30.1	51.3	17.5	0.7	4.1	65.2	1.3	15.7	8,338	11,090	-	-	-
"	"	Opencut	1967		24.8	37.8	42.9	19.3	2.5	-	-	-	-	7,516	9,907	-	-	-
"	"	"	1967		33.9	39.5	41.0	19.5	2.9	-	-	-	-	5,371	8,131	-	-	-
"	"	Outcrop	1967		29.5	49.8	48.7	11.4	1.1	-	-	-	-	7,366	10,472	-	-	-
"	"	"	1967		22.2	37.4	47.7	14.9	1.6	-	-	-	-	8,449	10,852	-	-	-
"	"	Mahn	1967		24.2	35.7	52.3	11.0	1.7	-	-	-	-	8,470	11,170	-	-	-
"	Zortman	Ruby-Gulch	1967		20.6	33.9	46.0	20.1	0.9	-	-	-	-	7,600	9,812	-	-	-
"	Winifred	Mills	1967		21.5	37.1	42.8	20.2	1.1	-	-	-	-	7,481	9,776	-	-	-
"	"	Opencut	1967		19.0	36.5	41.5	22.0	1.0	-	-	-	-	7,943	9,801	-	-	-
"	"	Outcrop	1967		25.4	35.9	46.0	18.1	0.8	-	-	-	-	8,194	10,292	-	-	-
"	"	"	1967		31.2	39.0	48.2	12.6	0.9	-	-	-	-	7,038	10,226	-	-	-
"	"	Cotton-wood	1967		22.7	35.4	48.8	15.7	1.1	4.4	63.9	1.0	11.0	8,483	10,985	-	-	-
"	Zortman	Open-Prospect	1967		12.5	35.5	44.3	20.2	0.7	-	-	-	-	6,958	8,540	-	-	-

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	[illegible]	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
MONTANA (continued)																		
Fergus	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	10,300	-	-	
Flathead	Flathead River	Outcrop	1967		22.7	41.8	46.8	11.9	2.8	-	-	-	-	8,801	11,307	-	-	-
Gallatin	Chestnut Trl. Trail Co.	Meade & Nellie	1967		7.1	16.7	74.8	9.5	0.6	3.9	82.1	1.3	2.2	[illegible]	[illegible]	-	-	-
"	Chestnut	Mountain Side	1967		5.4	28.0	36.1	47.4	0.4	[illegible]	53.6	0.9	5.2	9,010	9,250	-	-	-
"	Storrs	Washoe Copper Co. No.1	1967		4.8	11.5	38.1	10.2	0.5	-	-	-	-	-	-	-	-	-
"	"	Anaconda	1967		6.3	-	-	-	-	-	-	-	-	11,400	-	-	-	-
"	"	Washoe No. 1 [illegible]	1967		5.8	31.2	53.6	11.7	0.5	5.0	71.5	1.1	8.7	[illegible]	[illegible]	-	-	-
"	"	Storrs No. 1	1967		4.1	35.9	[illegible]	[illegible]	0.5	[illegible]	[illegible]	[illegible]	8.6	[illegible]	9,887	-	-	-
"	"	"	1967		[illegible]	-	-	-	-	-	-	-	-	[illegible]	-	-	-	-
Garfield	Jordan	Foster Prospect	1967		25.3	35.9	48.9	16.2	0.6	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1967		33.3	31.8	44.9	14.4	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	[illegible]	Prospect	1967		15.6	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
"	"	[illegible]	1967		7.8	32.8	37.2	30.1	1.9	-	-	-	-	[illegible]	[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Depth	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Glacier	Browning	J. M. Stone Prospect	1967		8.0	38.4	48.0	13.5	-	-	-	-	-	11,047	12,008	-	-	-
"	St. Marys	Paisley Prospect	1967		7.0	34.4	51.0	14.6	0.9	-	-	-	-	10,870	11,690	-	-	-
Golden Valley	Painted Rock	Chale	1967		11.6	35.0	46.6	18.4	1.1	-	-	-	-	10,010	11,330	-	-	-
"	2 mi S Lavina	Bennett	1967		10.4	34.7	48.5	16.8	2.0	4.6	64.0	1.6	11.2	10,200	11,400	-	-	-
"	18 mi SW Lavina	Caldwell	1967		10.4	33.1	49.0	17.9	1.9	-	-	-	-	10,100	11,280	-	-	-
Granite	Drummond	Prospect	1967		19.4	46.8	32.2	21.0	1.7	5.3	57.0	0.8	14.2	8,700	10,790	-	-	-
Hill	Havre	Statone	1967		29.2	37.7	52.8	9.5	1.0	4.5	65.0	1.3	18.7	7,840	11,070	-	-	-
"	"	Clark	1967		25.6	37.6	52.6	9.8	0.8	4.5	66.0	1.4	17.5	8,290	11,140	-	-	-
"	"	Electric	1967		22.8	38.0	44.8	17.2	1.0	-	-	-	-	7,900	10,260	-	-	-
"	"	Prospect	1967		8.4	19.0	71.6	9.4	1.2	-	-	-	-	11,170	12,200	-	-	-
"	"	Brown	1967		19.3	33.4	43.7	22.9	1.8	-	-	-	-	7,690	[illegible]	-	-	-
"	"	Scheman Prospect	1967		21.7	39.9	46.3	13.8	1.1	-	-	-	-	8,140	10,470	-	-	-
"	"	Kinney	1967		21.1	38.0	48.1	13.9	1.0	-	-	-	-	8,420	10,200	-	-	-
"	"	Barrett's	1967		21.5	37.3	45.3	17.4	0.8	-	-	-	-	7,950	10,000	-	-	-
"	"	Ajcutt	1967		24.1	35.0	51.4	13.6	0.9	-	-	-	-	8,170	10,700	-	-	-
"	"	"	1967		24.7	37.0	49.0	16.0	1.2	4.1	61.1	1.1	16.5	7,990	10,610	-	-	-
"	"	Havre	1967		22.0	30.5	56.2	13.3	0.8	4.1	61.6	1.3	19.0	[illegible]	[illegible]	-	-	-
"	Box Elder 12 mi S Havre	Blue Tump	1967		7.9	-	-	-	-	-	-	-	-	12,740	-	-	-	-

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Proximate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu, as received	Btu, dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Hill	Havre	Prospect	1967		25.5	39.1	49.8	10.9	1.1	-	-	-	-	8,179	11,002	-	-	-
"	"	"	1967		32.3	41.1	36.0	22.7	0.2	-	-	-	-	5,411	7,984	-	-	-
"	"	"	1967		33.7	45.4	40.4	14.2	3.8	-	-	-	-	5,777	8,756	-	-	-
"	"	"	1967		30.4	42.5	50.1	7.5	1.1	-	-	-	-	7,499	10,768	-	-	-
"	"	"	1967		40.1	42.9	33.7	23.3	0.7	-	-	-	-	4,532	7,571	-	-	-
"	"	"	1967		23.6	35.7	37.6	26.7	1.6	-	-	-	-	7,058	9,239	-	-	-
"	"	Wheatman	1967		26.9	45.8	39.0	15.2	1.0	4.1	58.2	1.1	15.7	7,250	9,915	-	-	-
"	Rudyard	Outcrop	1967		11.9	44.4	34.6	21.0	2.0	-	-	-	-	-	-	-	-	-
"	"	Moran & Stevens	1967		24.1	38.5	49.3	12.2	1.5	4.4	66.0	1.3	14.6	8,470	11,070	-	-	-
"	Havre	Prospect	1967		31.8	41.9	41.1	17.0	1.0	-	-	-	-	6,323	9,[illegible]	-	-	-
Judith Basin	Buffalo	Williams	1967		14.4	33.7	53.4	13.0	4.8	-	-	-	-	-	-	-	-	-
"	"	Dagger Canyon	1967		17.0	33.0	52.8	14.2	5.0	3.7	62.4	0.8	14.0	8,694	10,713	-	-	-
"	Utica	Shewan	1967		10.0	27.6	49.1	23.3	6.1	-	-	-	-	8,89[illegible]	9,879	-	-	-
"	Windham	Hughes	1967		11.3	29.1	52.4	18.5	5.1	3.7	60.3	0.8	11.7	9,220	10,390	-	-	-
"	"	Inman	1967		9.3	32.6	50.6	16.8	4.4	5.1	64.1	0.9	9.8	10,218	11,267	-	-	-
"	Geyser	Meredith	1967		10.2	27.6	50.4	22.0	3.4	-	-	-	-	-	-	-	-	-
"	Raynesford	[illegible]	1967		13.1	25.7	49.1	25.2	1.5	3.2	57.8	0.8	11.8	8,350	9,608	-	-	-
"	Geyser	Miller	1967		5.8	[illegible]	55.2	16.6	4.1	3.3	68.6	0.9	9.9	10,577	11,299	-	-	-
"	Moore	Knox	1967		9.2	32.7	47.7	19.6	10.1	-	-	-	-	9,668	10,647	-	-	-
"	"	Sharp	1967		15.7	35.2	52.0	12.9	1.3	-	-	-	-	-	-	-	-	-
McCone	Circle		1967		30.6	38.7	44.5	16.8	1.6	4.7	60.2	1.1	15.6	7,220	10,400	-	-	-
"	"	A.A.	1967		[illegible]	42.1	50.0	7.9	0.4	4.7	66.2	1.1	19.7	[illegible]	[illegible]	-	-	-
"	"	[illegible]	1967		[illegible]	44.7	46.7	8.6	0.6	4.7	[illegible]	1.2	19.6	7,400	11,713	-	-	-
"	"	Stubbendom No. 1	1967		[illegible]	39.1	50.2	10.7	0.4	4.7	64.7	1.2	19.2	6,410	[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Meagher	10 mi. S. of Dorsey	Bonus	1967		6.7	27.1	35.3	30.6	0.6	-	-	-	-	8,530	9,151	-	-	-
Missoula	Missoula	Hellgate	1967		25.2	14.0	34.5	26.2	1.0	-	-	-	-	-	-	-	-	-
"	"	"	1967		24.7	13.0	34.7	28.4	1.1	3.7	51.8	1.0	15.9	6,717	8,912	-	-	-
Musselshell	Bull Mountain		1967		17.0	-	-	-	-	-	-	-	12.9	8,597	-	-	-	-
"	"		1967		16.3	-	-	-	-	-	-	-	13.0	8,352	-	-	-	-
"	"		1967		15.2	37.1	55.6	7.3	1.1	4.6	72.9	1.2	12.9	10,130	12,460	-	-	-
"	"		1967		16.0	37.1	55.7	7.2	0.6	4.7	73.3	1.2	13.0	10,540	12,560	-	-	-
"	"		1967		18.9	-	-	-	-	-	-	-	-	8,638	-	-	-	-
"	"		1967		21.6	-	-	-	-	-	-	-	-	9,016	-	-	-	-
"	"		1967		18.6	-	-	-	-	-	-	-	-	9,892	-	-	-	-
"	"		1967		17.4	-	-	-	-	-	-	-	-	10,280	-	-	-	-
"			1967		13.9	37.7	54.0	8.3	0.7	4.9	72.2	1.1	12.8	10,890	12,650	-	-	-
"			1967		14.2	37.6	53.0	9.4	0.9	4.8	70.8	1.3	12.8	10,600	12,350	-	-	-
"	Roundup	Western Coal No.1	1967		14.5	38.1	53.1	8.8	0.8	4.9	71.7	1.2	12.6	10,670	12,480	-	-	-
"	"	Western Coal No.2	1967		13.9	36.2	49.3	14.5	0.9	4.5	67.1	1.1	11.9	10,010	11,630	-	-	-
"	"	Big Dome	1967		15.7	37.2	54.9	7.9	1.2	4.9	72.6	1.2	12.2	10,720	12,710	-	-	-
"	Klein	Bantam	1967		14.0	35.9	57.5	6.6	0.8	5.1	72.8	1.2	13.5	11,160	12,980	-	-	-
"	Roundup	Republic No.2	1967		11.7	34.0	56.7	9.3	0.6	4.8	72.8	1.1	11.4	10,090	12,550	-	-	-
"	"	"	1967		11.9	-	-	-	-	-	-	-	-	11,110	-	-	-	-
"	"	Roundup No.1	1967		17.0	[illegible]	32.8	9.7	0.7	-	-	-	-	10,290	12,400			
"	"	"	1967		17.3	35.7	54.3	10.0	0.5	-	-	-	-	11,090	12,330	-	-	-
"	"	"	1967		11.7	35.4	55.1	9.5	0.5	-	-	-	-	11,790	12,560	-	-	-
"	"	Republic No.2	1967		11.7	-	-	-	-	-	-	-	-	12,390	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
					MONTANA (continued)													
Musselshell	Roundup	Square-deal	1967		12.8	-	-	-	-	-	-	-	-	10,570	-	-	-	-
"	"	"	1967		12.6	-	-	-	-	-	-	-	-	10,840	-	-	-	-
"	"	"	1967		11.8	-	-	-	-	-	-	-	-	10,770	-	-	-	-
"	"	"	1967		12.2	-	-	-	-	-	-	-	-	10,930	-	-	-	-
"	"	"	1967		12.4	35.8	54.5	9.7	0.4	4.6	72.6	1.2	11.5	10,980	12,530	-	-	-
"	"	"	1967		12.2	-	-	-	-	-	-	-	-	10,690	-	-	-	-
"	"	Davis No.4	1967		14.5	36.9	55.5	7.6	0.9	-	-	-	-	10,350	12,110	-	-	-
"	"	Keene	1967		13.5	38.4	52.6	9.0	0.6	-	-	-	-	10,590	12,590	-	-	-
"	"	Nies	1967		12.3	-	-	-	-	-	-	-	-	10,450	-	-	-	-
"	"	Keene	1967		11.9	-	-	-	-	-	-	-	-	11,280	-	-	-	-
"	"	Nies	1967		12.3	-	-	-	-	-	-	-	-	10,800	-	-	-	-
"	"	"	1967		12.6	-	-	-	-	-	-	-	-	11,090	-	-	-	-
"	"	Keene	1967		12.0	35.5	57.9	6.6	0.5	4.9	73.9	1.2	12.9	11,360	12,900	-	-	-
"	"	Nies	1967		12.4	-	-	-	-	-	-	-	-	10,700	-	-	-	-
"	"	Nies Bros.	1967		12.7	36.5	54.9	8.6	0.5	4.7	73.5	1.2	11.5	11,010	12,610	-	-	-
"	"	Nies	1967		12.0	-	-	-	-	-	-	-	-	10,930	-	-	-	-
"	"	Nies Bros.	1967		12.2	73.2	55.8	7.6	0.4	4.7	74.0	1.2	12.7	11,300	12,870	-	-	-
"	"	Nies	1967		12.8	-	-	-	-	-	-	-	-	11,030	-	-	-	-
"	"	Roundup No.1	1967		13.6	37.7	54.1	8.2	0.7	-	-	-	-	10,990	12,710	-	-	-
"	"	Keene	1967		12.1	-	-	-	-	-	-	-	-	11,490	-	-	-	-
"	"	Prospect	1967		12.7	32.9	58.3	8.8	0.6	4.6	73.6	1.0	11.4	11,030	12,640	-	-	-
"	"	Commercial	1967		14.3	32.5	60.6	6.9	0.6	-	-	-	-	11,050	12,890	-	-	-
"	"	Roundup A	1967		15.0	-	-	-	-	-	-	-	-	10,500	-	-	-	-
"	"	"	1967		13.7	-	-	-	-	-	-	-	-	10,870	-	-	-	-
"	"	"	1967		12.9	-	-	-	-	-	-	-	-	10,810	-	-	-	-
"	"	"	1967		13.1	-	-	-	-	-	-	-	-	10,630	-	-	-	-
"	"	"	1967		14.1	-	-	-	-	-	-	-	-	10,570	-	-	-	-
"	"	"	1967		13.6	38.0	52.7	9.3	0.8	4.7	71.7	1.1	12.4	10,690	12,360	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening tempera- ture, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Mussel-shell	Roundup	Republic No.1	1967		11.4	37.5	60.1	7.2	0.5	-	-	-	-	11,090	12,710	-	-	-
"	"	Roundup No.1	1967		12.8	-	-	-	-	-	-	-	-	10,300	-	-	-	-
"	"	"	1967		13.8	-	-	-	-	-	-	-	-	11,010	-	-	-	-
"	"	"	1967		13.1	-	-	-	-	-	-	-	-	10,550	-	-	-	-
"	"	"	1967		13.2	31.1	57.3	9.6	0.6	4.8	72.1	1.1	11.3	10,820	12,460	-	-	-
"	"	"	1967		12.7	32.9	58.2	8.9	0.6	4.7	71.6	1.2	13.0	11,030	12,630	-	-	-
"	"	"	1967		12.2	-	-	-	-	-	-	-	-	11,030	-	-	-	-
"	"	"	1967		21.1	-	-	-	-	-	-	-	-	[illegible]	-	-	-	-
"	"	"	1967		13.1	-	-	-	-	-	-	-	-	10,710	-	-	-	-
"	"	"	1967		11.9	-	-	-	-	-	-	-	-	10,880	-	-	-	-
"	"	"	1967		12.3	36.3	54.2	9.5	0.5	4.8	72.1	1.2	11.9	10,890	12,410	-	-	-
"	"	Republic No.2	1967		13.7	32.5	59.9	7.6	0.6	-	-	-	-	11,160	12,950	-	-	-
"	"	"	1967		13.8	37.4	55.0	7.6	0.5	4.7	73.8	1.1	12.3	11,120	12,840	-	-	-
"	"	Johnnie's	1967		14.6	38.5	53.6	7.9	0.7	4.8	73.1	1.2	12.1	10,880	12,710	-	-	-
"	"	Gilbert Crawford	1967		15.9	37.3	54.0	8.7	0.6	4.9	72.2	1.3	12.4	10,450	12,580	-	-	-
"	Mussel-	Newcastle & Dodd	1967		20.7	36.1	56.3	7.6	1.0	-	-	-	-	9,740	12,280	-	-	-
"	"	Grant Prospect	1967		16.7	33.4	57.7	8.9	1.2	4.5	71.1	1.2	13.1	10,790	12,270	-	-	-
"	Wolf Spring	Surface Prospect	1967		20.7	33.5	58.3	8.2	0.6	-	-	-	-	9,270	11,690	-	-	-
"	Mussel-shell	Robins Prospect	1967		22.8	35.0	59.0	6.0	0.4	3.8	68.3	1.2	19.3	8,860	[illegible]	-	-	-
"	Lither	Carpenter Creek	1967		20.4	-	-	-	-	-	-	-	-	10,270	-	-	-	-
"	"	"	1967		20.1	-	-	-	-	-	-	-	-	10,710	-	-	-	-
"	"	"	1967		20.1	34.7	60.4	4.9	1.2	4.6	75.1	1.1	12.5	10,790	12,910	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									MONTANA (continued)									
Mussel-Shell	2 mi E Mussel-Shell	Black Diamond	1967		20.8	34.3	38.6	7.8	2.3	4.5	74.0	1.2	12.5	10,150	12,770	-	-	-
"	"	Grants Prospect	1967		28.7	35.3	30.2	6.3	1.8	-	-	-	-	7,290	10,150	-	-	-
"	Roundup	Mary McCreary & Anne Cheer Prospect	1967		29.4	35.9	33.0	9.1	0.5	-	-	-	-	7,290	10,150	-	-	-
"	"	Keen No.2	1967		19.0	30.6	50.9	9.0	1.2	-	-	-	-	9,610	11,870	-	-	-
"	"	"	1967		17.3	30.9	35.6	9.5	1.0	-	-	-	-	9,920	12,000	-	-	-
"	"	"	1967		20.1	35.3	56.5	8.2	1.0	-	-	-	-	9,710	12,200	-	-	-
"	"	Kuchta Prospect	1967		28.6	38.9	51.1	10.0	0.9	-	-	-	-	7,110	9,960	-	-	-
"	"	Surface Prospect	1967		18.4	36.8	54.0	11.2	2.0	4.8	65.0	1.0	15.3	9,320	11,490	-	-	-
"	Bull Mountain	Local	1967		18.1	33.2	61.7	5.1	1.1	4.2	73.9	0.9	14.8	10,420	12,730	-	-	-
"	1 mi SW Painted Rock	Shols	1967		11.6	30.2	45.6	18.4	1.1	-	-	-	-	10,010	11,330	-	-	-
Park	Meyersburg	Potters	1962		2.4	-	-	-	-	-	-	-	-	12,337	-	-	-	-
"	Livingston	Livingston	1967		6.2	12.6	59.4	28.0	0.7	4.1	57.4	0.9	8.6	9,790	10,450	-	-	-
"	Chestnut	Hoffman	1967		12.1	35.5	35.2	15.3	0.4	-	-	-	-	-	-	-	-	-
"	"	"	1967		10.4	32.0	33.5	34.5	0.5	-	-	-	-	-	-	-	-	-
"	"	"	1967		12.4	42.1	48.2	9.7	0.7	4.9	71.6	1.1	12.3	10,950	12,500	-	-	-
"	"	"	1967		11.2	38.5	42.5	19.0	0.7	4.5	60.6	1.0	14.2	9,420	10,960	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Free swelling index	Hardgrove grindability index
MONTANA (continued)																		
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	Chimney Rock	Nancy [illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
Phillips	Malta	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	*	*	*	*	*
"	[illegible]	Indian [illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
Pondera	Valier	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
Powder River			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"			1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Powder River	Coalwood	Ash Creek	1967		25.7	37.2	46.6	6.2	0.5	-	-	-	-	[illegible]	11,7[illegible]	-	-	-
"	"	North Star	1967		33.9	41.1	47.7	5.2	0.4	-	-	-	-	7,300	11,090	-	-	-
"	"	Cool Creek Strip	1967		30.0	41.9	51.1	7.0	0.7	4.5	69.4	1.1	17.3	8,160	11,660	-	-	-
"	Otter Creek	Core Samp.	1967		26.6	40.3	52.6	7.1	0.3	4.7	70.8	1.1	16.0	8,240	11,980	-	-	-
"	Broadus	Curran & Harvey	1967		32.8	39.8	50.0	11.7	0.4	4.3	65.0	1.0	18.1	7,360	10,920	-	-	-
"	"	Two Trees	1967		19.5	44.4	46.7	8.3	0.3	4.3	63.8	1.2	21.5	5,430	10,540	-	-	-
"	"	Peerless	1967		33.9	40.2	50.1	9.7	0.3	-	-	-	-	7,240	10,650	-	-	-
"	"	"	1967		34.6	40.4	51.1	8.5	0.4	4.4	68.6	1.2	15.1	7,220	11,040	-	-	-
"	"	V.Stabio Prospect	1967		29.0	44.1	11.4	0.5	-	-	-	-	-	6,390	9,010	-	-	-
"	Cache Creek	Core Sample	1967		32.0	43.4	47.8	8.8	0.3	4.7	68.7	1.1	18.4	7,650	11,250	-	-	-
"	Broadus	Black Diamond	1967		32.1	44.0	46.3	9.6	0.4	-	-	-	-	7,380	10,900	-	-	-
"	"	Superior	1967		33.5	42.5	48.5	9.0	0.6	-	-	-	-	7,290	10,970	-	-	-
"	"	Core Sample	1967		29.2	42.7	51.0	6.3	1.1	4.9	68.4	1.1	17.1	8,[illegible]	11,[illegible]	-	-	-
"	"	"	1967		30.4	40.7	53.1	6.2	1.2	4.7	72.1	1.2	16.6	8,330	12,000	-	-	-
"	"	"	1967		27.2	41.6	55.4	[illegible]	2.8	4.6	68.3	1.3	17.0	8,530	11,720	-	-	-
"	"	"	1967		28.1	41.3	52.7	6.0	0.5	4.5	70.2	1.3	17.4	8,670	12,0[illegible]	-	-	-
"	"	"	1967		27.9	43.0	[illegible]	7.[illegible]	1.4	4.8	70.2	1.3	16.3	8,680	12,0[illegible]	-	-	-
"	"	"	1967		27.9	41.1	[illegible]	9.1	2.5	4.5	67.1	1.2	18.7	8,[illegible]	11,[illegible]	-	-	-
Prairie	Terry Lignite	Strip Pit	1967		25.1	-	-	22.1	0.4	-	-	-	-	5,330	7,[illegible]	-	-	-
"	Fallon	Gifford	1967		33.5	38.8	44.2	17.0	1.0	-	-	-	-	-	-	-	-	-

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine																
County	Coal field or town	Name	Date of analysis	Seam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MONTANA (continued)																		
Prairie	Fallon		1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	*	*	*	*	*
[illegible]	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	*	*	*	*	*
Richland		Knife River Coal Co.	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	-
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	*	*	*	*	*
"		[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"		[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	Savage	Savage	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
Roosevelt	Culbertson	Butterfield	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	Open pit	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	Culbertson	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	Prospect	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	[illegible]	Prospect	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
Rosebud	Castle Rock	[illegible] Prospect	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	Colstrip	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
"	"	"	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*
"	"	Colstrip	1967		[illegible]	*	*	*	*	*	*	*	*	[illegible]	*	*	*	*

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu/lb As received	Btu/lb Dry	Ash-softening temperature, °F	Free swelling index	Hardgrove grindability index
								MONTANA (continued)										
Rosebud	Colstrip	Colstrip	1967		23.1	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		[illegible]	37.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.9	[illegible]	[illegible]	"	"	"
"	"	"	1967		21.9	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		25.8	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		23.9	41.4	47.7	10.9	1.2	3.8	62.9	1.3	20.1	[illegible]	10,190	"	"	"
"	"	"	1967		24.4	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		23.3	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		24.4	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		23.6	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		24.1	37.4	[illegible]	9.4	1.0	4.7	[illegible]	[illegible]	13.1	[illegible]	[illegible]	"	"	"
"	"	"	1967		25.5	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		23.8	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		24.6	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		25.2	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		24.8	37.4	53.8	9.1	0.8	4.5	69.9	1.1	13.8	[illegible]	"	"	"	"
"	"	"	1967		22.9	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		24.0	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		26.2	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		24.6	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		24.5	37.7	51.2	11.1	1.2	4.9	[illegible]	1.1	13.8	[illegible]	[illegible]	"	"	"
"	"	"	1967		26.4	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		23.6	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"
"	"	"	1967		22.8	[illegible]	51.9	13.1	1.4	[illegible]	[illegible]	1.1	[illegible]	[illegible]	[illegible]	"	"	"
"	"	"	1967		26.5	38.8	54.4	8.8	1.4	4.7	70.1	1.0	[illegible]	[illegible]	[illegible]	"	"	"
"	"	"	1967		25.4	37.4	52.6	9.9	1.0	4.8	69.1	1.0	[illegible]	[illegible]	[illegible]	"	"	"
"	"	"	1967		25.5	[illegible]	[illegible]	15.9	[illegible]	"	"	"	"	[illegible]	[illegible]	"	"	"
"	Lee	Prospect	1967		23.6	[illegible]	[illegible]	[illegible]	2.0	"	"	"	"	[illegible]	[illegible]	"	"	"
"	Forsyth	Wright	1967		23.7	[illegible]	[illegible]	[illegible]	[illegible]	"	"	"	"	[illegible]	[illegible]	"	"	"
"	"	Haney	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	"	"	"	"	[illegible]	[illegible]	"	"	"
"	"	McKay	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	"	"	"	"	[illegible]	[illegible]	"	"	"
"	"	Alderson	1967		[illegible]	"	"	"	"	"	"	"	"	[illegible]	"	"	"	"

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Ultimate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature °F	Free swelling index	Hardgrove grindability index
MONTANA (continued)																		
Rosebud	Ashland	[illegible]	1967		27.1	*	*	*	*	*	*	*	*	9,[illegible]	*	*	*	*
"	"	Brewster Arnold	1967		27.3	34.3	53.4	9.1	0.8	4.7	70.1	1.4	15.1	8,910	12,171	*	*	*
"	"	Kendrick	1967		28.3	41.5	53.3	6.6	0.4	4.3	69.4	1.2	21.0	8,231	11,570	*	*	*
Sheridan	Medicine Lake	Ted Young	1963		39.1	39.9	50.7	9.5	0.9	4.2	62.5	1.1	20.3	6,281	10,352	*	*	*
"	"	Deignan	1967		41.1	43.7	48.1	8.2	0.6	4.3	63.1	1.1	22.5	6,200	11,088	*	*	*
"	"	Jones	1967		41.6	45.7	44.8	9.5	0.7	3.7	57.8	1.1	27.6	5,290	9,040	*	*	*
		Acme	1967		38.7	48.4	41.2	10.4	1.0	3.8	58.6	1.8	25.6	6,140	9,710	*	*	*
"	Plentywood	Lee	1967		35.7	43.9	47.4	11.7	2.7	4.2	63.4	1.2	16.8	6,750	10,490	*	*	*
"	"	"	1967		37.2	37.0	44.1	8.5	1.6	4.4	75.8	1.1	19.1	6,850	10,910	*	*	*
"	Antelope	Richardson	1967		29.1	41.5	47.8	10.4	0.4	*	*	*	*	7,500	10,580	*	*	*
"	Medicine Lake	Coolridge	1967		40.4	41.1	46.3	12.6	0.7	4.1	58.0	1.0	22.6	5,930	9,780	*	*	*
"	Plentywood	Pierce Bros.	1967		41.3	42.4	46.1	11.5	0.7	*	*	*	*	7,170	10,000	*	*	*
"	"	Pierce	1967		39.3	45.2	42.7	12.3	1.0	*	*	*	*	6,750	10,290	*	*	*
"	Daleview	Marcus	1967		38.6	36.5	47.9	15.6	0.4	3.5	60.5	1.0	19.2	6,140	9,680	*	*	*
Stillwater			1967		12.3	35.5	44.3	20.2	0.7	*	*	*	*	8,350	9,450		*	*
"	Dean	Albertson	1967		7.0	32.3	47.6	20.1	0.5	*	*	*	*	10,110	10,880	*	*	*
"	"	Garrett	1967		7.5	41.2	51.6	7.2	1.1	5.3	74.7	1.6	13.2	11,180	12,130	*	*	*
"	"	"	1967		6.9	35.9	47.1	16.7	0.7	4.7	67.6	1.1	9.8	11,740	12,750	*	*	*
"	Nye	Loffer	1967		6.7	34.7	42.7	17.6	0.6	4.6	65.9	1.2	10.1	10,930	11,650	*	*	*
Toole	Shelby	W. Butte	1967		7.2	38.6	54.5	6.8	1.9	4.7	72.8	1.5	10.1	11,774	12,681	*	*	*

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis Moisture %	Volatile matter %	Fixed carbon %	Ash %	Sulfur %	Ultimate analysis Hydrogen %	Carbon %	Nitrogen %	Oxygen %	Btu as received	Btu dry	Ash softening temperature (°F)	Free swelling index	Hardgrove grindability index
									MONTANA (continued)									
Treasure	Big Horn	Prospect	1967		15.3	38.2	41.9	17.9	1.3	*	*	*	*	[illegible]	[illegible]	*	*	*
Valley	[illegible]	[illegible]	1967		45.4	41.1	45.4	13.1	[illegible]	5.6	[illegible]	1.1	[illegible]	5,620	[illegible]	*	*	*
"	"	Baldwin Bros.	1967		42.7	41.1	45.7	15.2	1.3	5.9	[illegible]	5.5	19.7	5,640	9,830	*	*	*
"	E. Sudbey	Planer	1967		41.5	39.7	45.5	14.9	[illegible]	*	*	*	*	[illegible]	9,100	*	*	*
Wheatland	Harlowton	Prospect	1967		10.4	29.9	35.8	34.4	0.6	*	*	*	*	7,211	8,048	*	*	*
"	"	Outcrop	1967		25.3	31.4	49.1	19.5	0.6	*	*	*	*	6,383	[illegible]	*	*	*
"	"	Prospect	1967		27.4	35.9	46.3	18.4	[illegible]	*	*	*	*	6,374	[illegible]	*	*	*
Wibaux		[illegible]	1967		[illegible]	[illegible]	44.7	13.1	[illegible]	*	*	*	*	5,092	10,240	*	*	*
"		State	1967		37.8	41.6	31.8	25.5	1.6	*	*	*	*	6,140	9,800	*	*	*
Yellowstone	18 mi NE Huntley	Prospect	1967		17.4	37.7	58.2	5.8	0.4	*	*	*	*	10,280	12,451	*	*	*
"	"	"	1967		18.6	35.4	57.1	4.5	1.0	*	*	*	*	9,940	12,160	*	*	*
"	Bull Mountain	Outcrop	1967		29.7	41.1	52.9	5.8	0.5	*	*	*	*	7,100	10,171	*	*	*
"	Bussey	Prospect	1967		24.6	44.6	37.2	19.6	0.5	2.8	56.9	0.9	21.5	6,208	8,233			
"	"	"	1967		17.4	37.8	54.6	7.7	0.6	4.2	71.5	1.1	16.9	10,121	12,262	*	*	*
"	Huntley	"	1967		21.6	38.5	56.5	4.1	0.9	*	*	*	*	9,024	[illegible]	*	*	*
"	Wolf-spring	Outcrop	1967		11.1	19.1	26.1	55.4	0.2	*	*	*	*	[illegible]	[illegible]	*	*	*
"	20 mi NE Pine Ridge	"	1967		*	*	*	*	*	*	*	*	*	*	*	*	*	*
									NEW MEXICO[7,46,101]									
McKinley	Gallup	[illegible]			[illegible]	[illegible]	[illegible]	7.1	.6	*	*	*	*	11,730	12,160	[illegible]	*	[illegible]
"	"	[illegible]		Black Diamond	[illegible]	[illegible]	[illegible]	[illegible]	.8	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

	Coal Field or Town	Mine			Proximate analysis, %				Ultimate analysis, %									
County		Name	Date of [illegible]	Seam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Btu as received	Btu [illegible]	Ash softening temperature °F	Free swelling index	Hardgrove grindability index
					NEW MEXICO (continued)													
McKinley	Gallup	Sundance		Black Diamond	17.2	44.2	48.1	7.7	.8	*	*	*	*	11,400	13,270	2,470	*	51
"	"	"		"	11.8	46.2	45.3	7.1	.8	*	*	*	*	11,530	13,090	2,410	*	*
"	"	"		"	11.7	44.5	45.5	7.2	.7	*	*	*	*	11,570	13,100	2,530	*	*
"	"	"		"	12.0	43.5	46.3	8.2	1.1	*	*	*	*	11,230	12,970	2,470	1(1)	*
"	"	"		"	9.5	44.2	45.1	10.7	.5	*	*	*	*	11,840	13,040	2,567	*	*
"	"	"		"	11.7	46.1	45.3	7.8	.8	*	*	*	*	11,600	13,140	2,450	*	*
"	"	"		"	12.5	44.1	46.2	7.7	.7	*	*	*	*	11,630	12,990	2,460	*	*
"	"	"		"	13.0	42.7	45.8	9.3	.8	*	*	*	*	11,350	12,840	2,390	1-1/2(2)	*
"	"	"		"	10.2	44.3	47.8	8.1	.9	*	*	*	*	11,580	12,900	2,330	*	*
"	[illegible]	Roberts			9.5	44.7	47.5	8.1	.8	*	*	*	*	11,760	13,010	2,600	*	*
"	Standing Rock	"			11.6	44.5	48.2	7.5	.5	*	*	*	*	11,960	13,380	*	*	*
Colfax	Raton	Brilliant			1.9	33.4	64.1	15.1	.8	5.1	73.0	1.3	7.8	13,110	*	*	*	*
"	"	Van Houten			2.2	37.2	49.8	11.2	.9	5.3	[illegible]	1.7	8.1	14,040	*	*	*	*
Santa Fe	Cook & White	Jones			3.9	11.7	18.7	13.1	.8	5.1	[illegible]	2.3	11.7	14,190	*	*	*	*
"	"	Lamb			2.6	36.5	58.2	7.1	.8	5.8	79.5	1.3	10.8	14,360	*	*	*	*
"	Miller Gulch	Miller Gulch			2.2	33.4	58.3	6.4	.7	5.6	79.5	1.5	9.5	14,130	*	*	*	*
Socorro	Carthage	Law Prospect			2.5	40.4	43.5	7.8	.8	5.2	73.5	1.4	10.9	14,680	*	*	*	*
McKinley	Gallup	Sundance		Black Diamond	12.7	44.9	47.8	7.1	.5	*	*	*	*	11,570	13,190	2,080	*	*
"	"	McKinley		[illegible]	13.1	44.1	46.6	9.3	.7	5.2	71.5	1.1	12.6	10,790	11,990	*	*	43

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
							NEW MEXICO (continued)											
Colfax	Dawson	Brilliant	194[illegible]	Raton	1.2	15.5	40.0	16.4	2.7	-	-	-	-	-	-	-	-	-
"	"	No. 2												12,460	[illegible]	2,910	-	-
"	"	"	1947	"	1.0	18.9	53.9	15.2	.7	5.0	71.2	1.8	7.1	12,480	[illegible]	2,910	-	-
"	"	Dawson No. 6	1944		1.5	38.7	48.0	12.5	.6	-	-	-	-	12,990	[illegible]	-	-	-
"	"	"	1948	"	1.5	38.5	48.6	11.3	.6	-	-	-	-	12,950	13,160	-	-	-
"	"	"	1949	"	1.3	38.8	47.0	13.9	.7	-	-	-	-	12,750	[illegible]	-	-	-
"	"	"	[illegible]	"	1.7	[illegible]	48.7	[illegible]	.7	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	Koehler	Koehler Nos. 1&2	1937	"	1.9	35.6	48.1	15.0	.6	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"		1950	"	1.0	35.1	47.1	17.1	.6	-	-	-	-	12,100	[illegible]	-	-	-
"	"	"	[illegible]	"	1.9	[illegible]	48.1	[illegible]	.7	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	.7	-	-	-	-	12,[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	.8	5.1	[illegible]	1.5	7.5	13,[illegible]	13,[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	2.0	[illegible]	50.5	11.6	.7	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"	1947	"	3.1	37.8	48.1	13.0	.6	-	-	-	-	12,[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	2.1	36.9	[illegible]	13.6	.7	-	-	-	-	12,[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	1.0	[illegible]	[illegible]	13.1	.8	-	-	-	-	12,[illegible]	[illegible]	-	-	-
"	"	"	1947	"	[illegible]	[illegible]	[illegible]	[illegible]	.6	-	-	-	-	12,[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	.7	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
McKinley	Gallup	Mutual	[illegible]	Amber	7.8	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	11,[illegible]	[illegible]	-	-	-
"	"	Navajo No. 5	[illegible]	Upper Bench [illegible]	[illegible]	[illegible]	[illegible]	7.5	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	41.3	[illegible]	7.1	.5	-	-	-	-	11,[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	12.7	[illegible]	[illegible]	[illegible]	.6	-	-	-	-	11,[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	11,[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	.6	-	-	-	-	11,[illegible]	[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	11,[illegible]	[illegible]	[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

	Coal field or town	Mine			Proximate analysis, %					Ultimate analysis, %				Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
County		Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
NEW MEXICO (continued)																		
McKinley	Mentmore	Mentmore	1941	Mesa Verde	9.9	40.6	50.[illegible]	9.5	.5	-	-	-	-	11,460	12,850	-	-	-
"	"	"	1950	"	7.2	40.3	44.9	9.2	.7	-	-	-	-	11,[illegible]	12,[illegible]	-	-	-
"	"	"	1949	"	9.1	41.[illegible]	[illegible]	7.4	.8	-	-	-	-	11,90[illegible]	12,7[illegible]	-	-	-
"	"	"	1950	"	8.5	[illegible]	47.0	7.8	.7	-	-	-	-	11,930	[illegible]	-	-	-
"	"	"	1950	"	9.8	45.4	45.[illegible]	9.0	.6	-	-	-	-	1[illegible],590	12,820	-	-	-
Rio Arriba	Lumberton	[illegible]	1941		7.8	40.8	52.[illegible]	7.0	2.1	-	-	-	-	11,460	12,730	-	-	-
"	"	"	1950		2.5	41.4	52.4	[illegible]	.4	-	-	-	-	11,[illegible]	14,130	-	-	-
"	"	"	1949		2.7	37.7	47.2	15.1	1.4	-	-	-	-	12,130	12,470	-	-	-
"	"	"	1950		3.7	38.[illegible]	48.1	13.5	1.1	-	-	-	-	1[illegible],1[illegible]	12,[illegible]	-	-	-
Sandoval	Cuba	Black Bone	1948		17.1	40.3	50.1	9.4	2.6	-	-	-	-	10,[illegible]	12,1[illegible]	-	-	-
Santa Fe	Madrid	Jones	1950	[illegible] White	1.3	33.9	54.3	11.8	1.0	-	-	-	-	12,[illegible]	13,[illegible]	-	-	-
"	"	"	1950		2.5	34.4	53.1	12.5	1.0	-	-	-	-	12,690	13,960	-	-	-
NORTH DAKOTA^{7,**}																		
Bowman	Gascoyne	Peerless East Pit			42.1	39.7	48.2	12.1	1.4	-	-	-	-	6,[illegible]	10,820	2,290	-	56
"	"	Peerless West Pit			40.7	45.0	[illegible]	9.5	1.7	-	-	-	-	6,[illegible]	10,90[illegible]	2,4[illegible]	-	46
Mercer	Beulah	Beulah Knife River			36.[illegible]	40.5	48.[illegible]	11.[illegible]	1.5	-	-	-	-	6,[illegible]	10,5[illegible]	2,[illegible]	-	5[illegible]
"	"	"			35.[illegible]	40.1	47.[illegible]	12.[illegible]	1.8	-	-	-	-	6,[illegible]	10,[illegible]	2,180	-	-
Ward	[illegible]	Velva		[illegible]	34.[illegible]	29.[illegible]	31.[illegible]	7.[illegible]	[illegible]	[illegible]	44.4	0.7	14.8	7,[illegible]	-	-	-	-
[illegible]	Larson	[illegible]			34.[illegible]	40.7	48.1	11.[illegible]	.8	-	-	-	-	7,[illegible]	10,[illegible]	2,100	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									NORTH DAKOTA (continued)									
Burke	Larson	Baukol-Noonan			33.4	40.2	49.8	9.9	.5	*	*	*	*	7,450	11,170	2,400	*	38
"	"	"			33.5	42.0	49.1	8.1	.4	*	*	*	*	7,530	11,320	2,130	*	*
"	"	"			31.6	41.5	49.8	7.7	.6	*	*	*	*	7,550	11,500	2,190	*	*
"	"	"			33.2	40.3	49.2	10.4	.5	*	*	*	*	7,400	11,100	2,120	*	*
"	"	"			34.7	39.6	50.4	10.0	.6	*	*	*	*	7,310	11,120	2,170	*	*
"	"	"			34.9	38.2	47.3	14.5	.8	*	*	*	*	7,020	10,840	2,090	*	*
Mercer	Beulah	Beulah			35.9	41.6	51.0	7.4	.7	*	*	*	*	7,050	11,000	2,470	*	*
"	"	"			36.5	41.5	50.3	8.2	.9	*	*	*	*	6,950	10,990	2,460	*	*
"	"	"			35.5	41.1	51.4	8.9	.8	*	*	*	*	6,900	10,850	2,070	*	*
"	"	"			35.6	38.1	50.7	13.9	.8	*	*	*	*	6,950	10,450	2,150	*	52
"	"	Beulah South			37.8	40.9	49.7	9.4	.9	*	*	*	*	6,990	10,950	2,430	*	54
"	Hazen	Dakota Star			34.0	42.4	48.7	8.9	.8	*	*	*	*	7,280	11,050	2,340	*	*
"	Zap	Indian Head			35.2	40.9	47.4	11.7	.6	*	*	*	*	7,200	10,850	2,120	*	*
Burke	Columbus	Kincaid			34.4	40.1	48.8	11.1	1.0	*	*	*	*	7,077	10,800	2,170	*	*
Divide	Noonan	Baukol-Noonan			33.8	41.0	49.2	9.8	.4	*	*	*	*	7,475	11,350	2,150	*	*
"	"	"			33.8	41.0	48.7	10.3	.6	*	*	*	*	7,430	11,240	2,230	*	*
Mercer	Beulah	Beulah Knife River			34.2	44.0	45.6	10.7	1.0	*	*	*	*	7,080	10,880	2,190	*	*
"	Zap	Indian Head			33.1	42.8	48.8	8.4	.6	*	*	*	*	7,410	11,240	*	*	*
Ward	Velva McHenry County	Velva			37.6	33.9	49.2	7.1	.6	*	*	*	*	6,730	10,670	2,410	*	*

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine	Date of sampling	Type	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Dry Btu	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Proximate analysis, %					Ultimate analysis, %								
					NORTH DAKOTA (continued)													
Ward	[illegible] County	Velva		auger-drilled	37.3	44.2	48.1	8.9	.5	-	-	-	-	6,750	11,030	2,380	-	-
[illegible]	[illegible]	[illegible]		"	40.1	43.1	37.7	19.4	1.7	-	-	-	-	7,110	11,850	2,180	-	63
"	"	"		"	33.5	40.3	40.8	19.1	1.4	-	-	-	-	6,870	11,570	2,790	-	-
Bowman	Gascoyne	Gascoyne-Peerless		"	41.5	43.5	44.3	11.5	1.8	-	-	-	-	6,300	10,770	2,210	-	-
Burke	Larson	Noonan		"	32.8	41.4	47.5	10.0	.3	-	-	-	-	7,370	10,970	2,100	-	46
"	"	"		"	37.3	41.3	46.7	8.8	.3	-	-	-	-	7,600	11,120	2,090	-	-
[illegible]	Beulah	Beulah		"	34.7	42.2	48.7	9.1	.7	-	-	-	-	7,170	11,000	2,370	-	-
Ward	Kenmare	Velva		"	33.3	42.9	51.2	5.1	.3	-	-	-	-	6,940	10,800	2,050	-	58
"	"	"		"	34.1	41.2	45.6	7.0	.3	-	-	-	-	7,190	10,950	2,040	-	-
"	"	"		"	40.1	40.7	53.9	5.8	.3	-	-	-	-	6,410	10,780	2,470	-	-
"	Velva [illegible] County	Velva			37.0	43.1	48.5	7.8	.2	-	-	-	-	6,750	11,020	2,500	-	-
Burke	Columbus	Kincaid			31.4	38.3	51.1	6.6	.6	-	-	-	-	7,250	11,110	2,060	-	-
"	"	"			34.3	39.7	45.1	15.5	.5	-	-	-	-	7,180	11,020	2,050	-	-
"	"	"			31.2	41.1	46.1	12.9	.5	-	-	-	-	7,100	10,680	2,060	-	-
"	"	"			34.7	35.5	43.7	20.0	.3	-	-	-	-	6,430	9,840	2,050	-	-
"	Larson	Noonan			31.3	40.6	46.2	13.2	.4	-	-	-	-	7,410	11,100	2,085	-	-
"	"	"			31.3	40.1	46.1	13.4	.4	-	-	-	-	7,460	11,090	2,130	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or bed	Mine: Name	Mine: Date of sampling	Rank	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Proximate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu, as received	Btu, dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					NORTH DAKOTA (continued)													
Mercer	[illegible]	Dakota Star			35.1	42.1	45.1	3.1	[illegible]	-	-	-	-	7,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"			[illegible]	42.[illegible]	45.[illegible]	[illegible]	.3	-	-	-	-	7,[illegible]	11,[illegible]	2,[illegible]	-	-
"	Zap	Indian Head			35.1	40.8	[illegible]	[illegible]	.3	-	-	-	-	7,[illegible]	11,[illegible]	2,050	-	39
"	"	"			39.0	41.0	50.3	11.3	1.7	-	-	-	-	7,[illegible]	10,[illegible]	2,[illegible]	-	-
"	"	"			34.8	42.4	48.5	11.6	1.2	-	-	-	-	7,040	10,820	2,100	-	-
Ward	Velva McHenry County	Velva			35.[illegible]	43.1	55.[illegible]	4.5	.6	-	-	-	-	7,[illegible]	11,[illegible]	2,500	-	39
"	"	"			37.[illegible]	41.4	49.[illegible]	1.5	.6	-	-	-	-	6,780	11,[illegible]	2,[illegible]	-	-
"	"	"			36.5	41.5	45.[illegible]	[illegible]	.3	-	-	-	-	7,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"			38.2	43.[illegible]	49.[illegible]	5.5	.4	-	-	-	-	6,943	10,885	2,470	-	-
Adams	Haynes	Arrowhead	1947		35.4	42.2	44.5	13.3	1.8	4.1	63.1	0.8	16.7	6,960	10,781	2,180	-	-
"	"	"	1947		35.9	45.0	41.2	13.8	2.5	-	-	-	-	7,000	10,940	2,190	-	-
"	"	"	1947		39.3	42.8	37.8	19.3	2.9	-	-	-	-	6,440	9,900	2,150	-	-
"	"	Pearl Butte	1947		36.6	44.7	40.[illegible]	15.[illegible]	1.7	4.7	61.6	0.9	15.9	7,280	11,190	2,340	-	-
"	"	"	1947		35.5	37.1	41.8	11.0	2.1	-	-	-	-	7,190	11,140	2,280	-	-
Bowman	Haynes	Bowman State Slattery	1946		40.3	40.6	43.7	15.[illegible]	1.[illegible]	4.5	53.8	1.3	17.0	5,[illegible]	10,[illegible]	2,470	-	-
Burke	Columbus	Kincaid	1946		35.1	43.4	50.1	7.8	[illegible]	4.3	66.4	1.2	18.[illegible]	7,180	11,180	2,190	-	-
"	"	"	1946		35.7	42.1	48.7	9.1	[illegible]	-	-	-	-	7,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	1946		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	10,[illegible]	2,[illegible]	-	-
"	"	"	1946		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	10,[illegible]	2,[illegible]	-	-

Table D-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

	Coal Field or [illegible]	Mine Name	Date of Sample [illegible]	Seam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Btu/lb, as received	Btu/lb, dry	Ash Softening Temperature, °F	Free Swelling Index	Hardgrove Grindability Index
									NORTH DAKOTA (continued)									
[illegible]	Wilton	[illegible]	1967		47.1	40.5	46.8	3.9	1.0	4.6	72.0	1.3	19.5	7,000	11,[illegible]	2,140	-	-
"	"	[illegible]	1967		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
Stark	[illegible]	[illegible]	1946	[illegible]	34.3	41.5	50.7	7.8	0.8	4.4	66.1	1.2	19.1	6,490	11,[illegible]	2,140	-	-
"	"	"	1946	"	35.4	41.1	45.1	9.8	[illegible]	-	-	-	-	7,180	11,[illegible]	2,730	-	-
"	"	"	1946	"	35.5	41.2	46.8	12.0	1.8	-	-	-	-	7,060	10,[illegible]	2,180	-	-
[illegible]	[illegible]	[illegible]	1967		38.3	51.9	40.2	7.9	0.6	-	-	-	-	6,730	11,[illegible]	2,[illegible]	-	-
"	"	"	1967		33.5	40.1	49.5	[illegible]	[illegible]	4.6	68.6	1.1	20.5	6,810	11,[illegible]	2,[illegible]	-	-
Williams	Williston	Avoca	1946		41.3	41.4	47.8	8.7	1.0	-	-	-	-	6,[illegible]	11,[illegible]	1,[illegible]	-	-
"	"	"	1946		41.2	41.5	47.9	[illegible]	1.0	4.6	[illegible]	1.0	[illegible]	6,[illegible]	11,[illegible]	2,150	-	-
"	"	"	1946		40.8	41.0	44.0	14.4	1.0	-	-	-	-	6,070	10,[illegible]	2,080	-	-
"	"	"	1946		41.1	38.3	44.7	15.2	0.5	-	-	-	-	[illegible]	10,[illegible]	2,100	-	-
"	"	Holland	1946		40.8	41.8	47.9	[illegible]	0.7	4.4	[illegible]	1.1	19.7	6,380	11,[illegible]	2,320	-	-
"		Square Deal	1946		[illegible]	[illegible]	48.8	7.8	0.4	4.5	[illegible]	1.2	19.5	[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	1946		40.8	41.8	47.2	11.0	1.4	4.8	[illegible]	1.1	[illegible]	[illegible]	10,[illegible]	2,[illegible]	-	-
"	"	"	1946		38.1	39.1	38.4	[illegible]	[illegible]	-	-	-	-	5,[illegible]	9,[illegible]	2,[illegible]	-	-
"	"	Williston [illegible]	1946		[illegible]	44.0	48.1	7.8	[illegible]	4.7	[illegible]	1.2	19.5	6,[illegible]	11,[illegible]	2,[illegible]	-	-
"	"	"	1946		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	10,[illegible]	2,140	-	-
[illegible]	[illegible]	[illegible]	1971	Middle	4.2	40.5	46.[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	13,[illegible]	2,[illegible]	-	-
"	"	"	1971	[illegible]	5.1	40.4	[illegible]	[illegible]	-	-	-	-	-	11,[illegible]	1[illegible]	[illegible]	-	-
[illegible]	[illegible]	[illegible]		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10,[illegible]	11,[illegible]	[illegible]	-	-
"	[illegible]	[illegible]		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	1[illegible]	[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %					Ultimate analysis, %				Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
NORTH DAKOTA (continued)																		
Ward	Sawyer	Miller Strip	1946		39.0	42.3	51.0	6.7	0.3	4.4	67.2	0.9	20.5	6,880	11,280	2,470	-	-
"	"	"	1946		[illegible]	41.5	49.5	9.0	0.4	-	-	-	-	6,780	[illegible]	[illegible]	-	-
"	"	"	1946		38.9	41.7	48.0	10.3	0.4	-	-	-	-	6,650	10,890	[illegible]	-	-
"	"	"	1946		40.3	39.4	46.9	13.7	0.4	-	-	-	-	6,190	10,370	[illegible]	-	-
"	"	"	1946		40.8	38.8	46.6	14.6	0.4	-	-	-	-	6,020	10,170	2,210	-	-
"	"	Vis	1946	Octemu	39.8	44.2	49.0	6.8	0.3	4.6	56.0	1.0	21.3	6,740	11,180	2,380	-	-
"	"	"	1946	"	38.7	44.0	47.8	8.2	0.3	-	-	-	-	6,740	11,000	2,310	-	-
"	"	"	1946	"	38.6	43.1	48.7	8.2	0.4	-	-	-	-	6,730	10,960	2,310	-	-
"	"	"	1946	"	38.4	41.4	47.8	10.8	0.7	-	-	-	-	6,580	10,690	2,130	-	-
"	"	West Side	1946	"	38.5	42.9	49.3	7.8	0.3	4.4	65.9	1.0	20.6	6,820	11,080	2,250	-	-
"	"	"	1946	"	38.2	42.1	47.2	10.7	0.3	-	-	-	-	6,710	10,850	2,220	-	-
"	"	"	1946	"	38.3	40.7	46.6	12.7	0.4	-	-	-	-	6,450	10,460	2,170	-	-
"	"	"	1946	"	39.2	39.4	46.1	14.5	0.6	-	-	-	-	6,240	10,250	2,160	-	-
"	Velum	Velum	1946	"	39.1	43.9	49.8	6.3	0.4	4.5	66.1	0.9	21.8	6,810	11,180	2,660	-	-
"	"	"	1946	"	39.1	43.6	49.4	7.0	0.3	-	-	-	-	6,760	11,090	2,530	-	-
"	"	"	1946	"	38.6	43.3	48.5	8.2	0.3	-	-	-	-	6,720	10,940	2,520	-	-
"	"	"	1946	"	38.5	43.3	47.4	9.3	0.3	-	-	-	-	6,660	10,830	2,450	-	-
"	"		1973		37.6	43.1	48.0	8.9	0.5	-	-	-	-	6,750	10,810	2,450	-	-
Williams	Tioga	M & M	1946		41.7	44.0	47.7	8.3	0.7	4.5	65.6	1.1	19.8	6,530	11,190	2,530	-	-
"	"	"	1946		41.8	42.7	47.5	9.8	0.6	-	-	-	-	6,420	11,020	2,380	-	-
"	"	"	1946		41.0	42.3	46.5	11.2	0.6	-	-	-	-	6,390	10,840	2,180	-	-
"	"	"	1946		41.4	41.2	44.0	14.8	0.7	-	-	-	-	6,080	10,380	2,230	-	-
"	"	"	1946		42.6	40.1	42.7	17.2	0.9	-	-	-	-	5,810	10,130	2,220	-	-
"	Wheelock	Cedar Coulee # 2	1946		42.9	43.1	48.4	8.5	0.6	4.4	65.0	1.0	20.5	6,350	11,120	2,150	-	-
M'Lean	Underwood	Pigeonskin	1947		41.0	45.3	46.7	8.0	0.8	4.5	65.6	1.3	20.1	6,610	11,200	2,580	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Bed	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								NORTH DAKOTA (continued)										
McLean	Underwood	[illegible]	1947		40.2	45.0	45.3	9.7	0.8	-	-	-	-	6,600	11,040	2,230	-	-
"	"	"	1947		39.9	44.6	44.3	11.1	0.9	-	-	-	-	6,570	10,920	2,360	-	-
"	"	"	1947		[illegible]	41.0	44.2	14.8	0.9	-	-	-	-	6,210	10,380	2,180	-	-
Mercer	Hazen	Dakota Star	1947		37.7	44.0	48.9	7.1	0.8	4.5	66.1	0.9	20.4	6,980	11,210	2,000	-	-
"	"	"	1947		37.4	41.9	48.4	9.7	1.1	-	-	-	-	6,950	11,100	2,380	-	-
"	"	"	1947		37.3	43.3	47.4	9.3	0.7	-	-	-	-	6,970	11,120	2,390	-	-
"	Zap	Indian Head	1947	Beulah Zap	35.9	42.6	47.8	9.6	1.2	4.3	66.9	0.9	18.1	7,150	11,130	2,260	-	-
"	"	"	1947	"	35.6	42.4	47.3	10.3	1.0	-	-	-	-	7,120	10,080	2,190	-	-
"	"	"	1947	"	35.9	41.2	47.6	11.2	1.0	-	-	-	-	7,000	10,920	2,200	-	-
Morton	Glen Ullin	Richter	1947		42.1	43.6	45.8	10.6	1.8	4.4	64.4	1.1	17.7	6,300	10,880	[illegible]	-	-
"	"	"	1947		40.4	41.0	39.6	19.4	1.8	-	-	-	-	5,840	9,800	2,500	-	-
"	"	"	1947		41.0	35.6	32.7	31.7	1.3	-	-	-	-	4,720	7,990	2,100	-	-
Mount Rail	White Earth	Tinnel	1946		43.1	42.0	51.6	6.4	0.4	4.4	65.9	1.2	26.7	6,430	11,310	2,420	-	-
Ward	Minot	Quality Lignite	1946		39.0	42.8	50.2	7.0	0.1	4.4	66.2	1.0	21.3	6,780	11,100	2,540	-	-
"	"	"	1946		35.2	40.5	49.4	10.1	0.3	-	-	-	-	6,560	10,620	2,290	-	-
"	"	"	1946		38.1	40.8	48.5	10.7	0.2	-	-	-	-	6,500	10,530	2,300	-	-
"	"	"	1946		38.6	39.4	47.3	13.3	0.4	-	-	-	-	6,270	10,210	2,240	-	-
								OREGON*										
-	Coos Bay				16.3	34.6	41.1	8.0	0.6	-	-	-	-	-	11,950	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera- ture, °F	Free swelling index	Hardgrove grindability index
									OREGON (continued)									
-	Eden Ridge	Argo Anderson			4.6	35.7	31.7	32.6	-	-	-	-	-	-	8,350	-	-	-
-	"	Argo Carter			2.7	31.3	28.2	40.5	-	-	-	-	-	-	6,900	-	-	-
-	Rogue River Valley	-			9.1	30.0	31.8	29.1	1.5	-	-	-	-	-	8,500	-	-	-
									SOUTH DAKOTA⁴⁷									
Dewey	Firesteel	Firesteel			33.4	43.2	46.7	10.1	.9	-	-	-	-	7,330	11,000	2,210	-	-
"	"	"			32.8	42.4	42.8	14.8	1.6	-	-	-	-	7,140	10,630	2,020	-	40
"	"	"			32.1	38.8	38.5	22.7	1.4	-	-	-	-	6,440	9,490	2,080	-	-
									UTAH¹⁶,⁴⁷,⁴⁸,¹⁰¹									
Carbon	Helper	Carbon Fuel		Castle Gate B	4.5	45.3	47.4	7.3	.3	-	-	-	-	12,720	13,320	2,160	-	-
"	"	"		"	4.8	45.0	47.4	7.6	.3	-	-	-	-	12,640	13,280	2,270	-	-
"	"	Liberty		Castle Gate B & Liberty	5.5	47.7	47.7	4.6	.9	-	-	-	-	13,070	13,830	1,990	-	-
"	"	"		"	5.3	47.4	48.3	4.3	.9	-	-	-	-	13,090	13,830	2,080	-	48
"	"	"		"	5.5	46.5	46.6	6.9	1.0	-	-	-	-	12,730	13,460	2,080	-	-
"	"	"		"	6.3	45.2	47.2	7.6	.9	-	-	-	-	12,150	13,290	2,080	2	-
"	"	"		"	6.1	47.2	46.3	6.5	1.0	-	-	-	-	12,630	13,440	2,080	2	-
"	"	Spring Canyon No.7		Castle Gate D	3.1	47.5	44.6	7.9	.4	-	-	-	-	12,990	13,410	2,130		
"	"	"		"	3.4	47.2	45.0	7.8	.4	-	-	-	-	12,950	13,410	2,090	-	40
"	"	"		"	3.3	47.2	45.1	7.7	.4	-	-	-	-	12,890	13,320	2,130	-	-
"	"	"		"	3.7	47.3	44.9	7.8	.4	-	-	-	-	12,820	13,310	2,130	-	-
"	"	"		"	4.6	46.1	45.8	8.1	.4	-	-	-	-	12,680	13,290	2,130	1	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Helper	Spring Canyon No.7		Castle Gate D	5.5	47.3	45.4	7.3	.4	5.7	74.0	1.4	11.2	12,640	13,380	2,090	1	-
"	Hiawatha	King			7.2	43.5	50.0	5.4	.5	-	-	-	-	12,630	13,610	2,080	-	-
"	"	"			6.2	45.1	49.6	5.3	.5	-	-	-	-	12,920	13,760	[illegible]	-	-
"	"	"			7.1	44.5	50.7	.8	.5	-	-	-	-	12,800	13,770	2,060	-	-
"	"	"			7.3	45.9	49.1	5.0	.5	-	-	-	-	12,810	13,810	2,050	-	-
"	"	"			6.2	45.5	49.1	5.4	.5	-	-	-	-	12,880	13,740	2,060	-	48
"	"	"			7.0	46.2	49.7	4.6	.5	-	-	-	-	12,920	13,890	2,050	2 1/2	-
"	"	"			6.1	45.9	45.6	5.5	.6	-	-	-	-	12,920	13,770	2,040	-	-
"	"	"			6.1	45.3	40.2	5.5	.5	-	-	-	-	12,930	13,770	2,040	-	-
"	"	"			7.0	45.9	49.3	4.8	.5	-	-	-	-	12,860	13,830	2,050	-	-
"	"	"			6.7	46.1	48.7	5.2	.4	-	-	-	-	12,870	13,800	2,080	-	-
"	"	"			5.6	46.9	49.6	3.5	.5	-	-	-	-	13,250	14,040	2,050	1	-
"	Kenilworth	Kenilworth			4.0	45.3	46.9	7.8	.3	-	-	-	-	12,820	13,370	2,180	2 1/2	-
"	Rains	Western			3.9	47.3	47.2	[illegible]	.6	-	-	-	-	[illegible]	13,780	-	-	-
"	"	"			4.5	47.0	46.9	6.1	.7	-	-	-	-	[illegible]	13,640	2,080	-	-
"	Wellington	Knight Ideal No.2			3.5	41.4	54.2	4.4	.4	-	-	-	-	13,390	13,880	-	-	-
"	"	"			4.4	40.8	54.3	4.9	.4	-	-	-	-	13,250	13,860	-	-	-
"	"	"			5.5	40.7	53.9	5.4	.5	-	-	-	-	12,930	13,740	2,180	-	-
"	"	"			3.7	41.3	53.2	5.5	.6	-	-	-	-	13,270	13,790	2,200	-	-
"	"	"			5.4	41.1	53.6	5.3	.5	-	-	-	-	13,070	13,830	2,190	-	-
"	"	"			4.9	41.3	53.2	[illegible]	.5	-	-	-	-	13,020	13,710	2,150	-	-
"	"	"			6.2	40.7	53.7	5.6	.5	-	-	-	-	12,830	13,663	2,130	-	-
Emery	Castle Gate	Buck Cliffs		Lower Sunnyside	5.7	41.2	51.8	7.0	.6	-	-	-	-	12,630	13,400	2,410	-	-
"	"	"		"	5.7	41.0	51.8	7.2	.6	-	-	-	-	12,650	13,420	2,490	-	-
"	"	"		"	6.2	41.1	52.5	5.4	.6	-	-	-	-	12,750	13,630	-	-	-
Carbon	"	Clear Creek Castle Gate prep. plant		Castle Gate A	8.2	43.7	51.3	5.0	.4	-	-	-	-	12,400	13,510	2,620	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu/lb as received	Btu/lb dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Castle Gate	Clear Creek Castle Gate prep. plant		Castle Gate A	3.6	44.7	51.1	4.7	.5	5.4	76.0	1.4	12.0	12,240	13,530	2,520	-	-
"	"	"		"	8.2	42.3	51.7	5.5	.4	-	-	-	-	12,160	13,250	2,360	1	-
"	"	Kenilworth			4.3	43.7	48.6	7.7	.4	-	-	-	-	12,730	13,320	2,180	-	-
"	"	Kenilworth & Castle Gate No.4 Castle Gate prep plant			3.1	42.3	50.4	7.3	.5	-	-	-	-	12,920	13,330	2,120	-	43
"	"	"			5.6	42.8	49.3	7.9	.5	-	-	-	-	12,500	13,240	2,130	-	-
"	"	"			5.7	43.4	50.4	6.2	.4	-	-	-	-	12,760	13,490	2,130	-	-
"	"	"			6.6	43.0	51.0	6.0	.4	-	-	-	-	12,590	13,470	2,160	1 1/2	-
"	Helper	Carbon Fuel		Castle Gate P	3.4	45.0	48.0	7.0	.3	-	-	-	-	12,830	13,290	-	-	-
"	"	"		"	3.0	46.2	47.1	6.7	.4	-	-	-	-	13,030	13,440	2,240	-	-
"	"	"		"	4.4	44.7	48.5	6.8	.3	-	-	-	-	12,800	13,390	-	-	-
"	Hiawatha	King			6.7	45.6	48.2	6.2	.6	-	-	-	-	12,690	13,610	2,210	-	-
"	Mains	Western			3.6	47.9	46.3	5.3	.8	-	-	-	-	13,340	13,860	-	-	-
"	"	"			4.3	46.7	46.4	6.9	.8	-	-	-	-	12,910	13,510	2,120	-	-
"	Scofield	Standard Columbine		Castle Gate B	7.3	44.4	49.5	6.1	.6	5.5	74.8	1.4	11.6	12,390	13,360	2,480	-	-
"	"	"		"	6.5	44.3	48.1	7.6	.7	-	-	-	-	11,760	12,850	2,150	1	-
"	Wellington	Knight Ideal No.2			3.8	40.7	53.3	6.0	.6	-	-	-	-	13,130	13,670	2,210	-	-
"	"	"			5.9	40.6	53.4	6.0	.5	-	-	-	-	12,800	13,610	2,130	-	-
Emery	Wellington	Book Cliffs		Lower Sunnyside	4.9	40.6	43.1	6.3	.7	-	-	-	-	12,790	13,440	-	-	-
"	"	"		"	6.0	40.8	52.5	6.7	.6	-	-	-	-	12,530	13,430	-	-	-
"	"	"		"	6.4	41.1	52.6	6.3	.6	-	-	-	-	12,610	13,450	[illegible]	-	-
"	"	"		"	5.9	40.7	52.3	7.0	.7	-	-	-	-	12,590	13,380	2,340	-	21

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, %: Hydrogen	Carbon	Nitrogen	Oxygen	Btu, as received	Btu, dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									UTAH (continued)									
Emery	Wellington	Book Cliffs		Lower Sunnyside	5.8	41.1	52.1	6.0	.8	-	-	-	-	12,670	13,470	2,400	-	-
"	"	"		"	6.6	41.3	52.5	6.0	.6	-	-	-	-	12,550	13,440	2,520	-	-
Carbon	Castle Gate	Kenilworth			4.4	41.9	48.0	8.2	.4	-	-	-		12,720	13,300	-	-	-
"	"	Carbon Fuel		Castle Gate B	4.5	45.8	47.1	6.9	.3	-	-	-	-	12,850	13,450	2,250	2 1/2	-
"	"	"		"	4.7	45.7	47.4	6.9	.3	-	-	-	-	12,810	13,450	2,270	3	-
"	"	"		"	4.7	45.5	47.3	7.1	.3	-	-	-	-	12,780	13,410	-	-	-
"	Hiawatha	King			4.8	47.0	46.4	6.1	.5	-	-	-	-	12,980	13,650	2,300	-	-
"	"	"			6.4	45.9	48.4	5.7	.5	-	-	-	-	12,820	13,700	2,140	-	-
"	"	"			5.9	46.1	47.7	5.2	.6	-	-	-	-	12,850	13,660	-	-	-
"	Rains	Western			3.5	46.9	46.9	6.2	.8	-	-	-	-	13,140	13,[illegible]	-	-	-
"	"	"			[illegible]	46.[illegible]	47.[illegible]	5.8	.7		-	-	-	13,020	13,550	2,100	-	-
"	"	"			4.2	44.6	46.9	8.5	.7	-	-	-	-	12,720	13,280	2,100	-	-
"	"	"			4.3	45.0	46.8	8.2	.8	-	-	-	-	12,630	13,200	2,180	-	-
"	Wellington	Knight (Ideal No.)			4.[illegible]	40.7	54.1	5.2	.5	-	-	-	-	13,390	13,[illegible]	-	-	-
"	"	"			3.5	40.9	54.0	5.1	.8	-	-	-	-	13,350	13,940	2,220	-	-
"	"	"			5.1	40.7	54.1	5.2	.4	-	-	-	-	14,100	14,800	2,200	1 1/2	-
"	"	"			4.6	40.8	54.4	4.8	.4	-	-	-	-	13,280	13,830	-	-	-
"	"	"			5.7	40.[illegible]	54.1	5.4	.4	-	-	-	-	12,900	13,690	-	-	-
Emery	Dragerton (Carbon county)	Book Cliffs		Lower Sunnyside	6.4	40.4	51.5	8.1	1.0	-	-	-	-	12,180	13,[illegible]	2,350	3	48
"	"	"		"	6.3	40.8	51.0	8.2	.8	-	-	-	-	12,400	13,230	2,400	-	-
"	"	"		"	5.5	40.6	51.9	7.5	.7	-	-	-	-	12,580	13,310	2,430	1	-
"	"	"		"	5.4	40.5	52.0	7.5	.7	-	-	-	-	12,560	13,340	2,450	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
					UTAH (continued)													
Carbon	Helper	Carbon Fuel		Castle Gate B	5.2	45.3	47.5	7.2	.3	-	-	-	-	12,670	13,370	2,190	1-1/2 2-1/2 1	-
"	"	Spring Canyon Tipple		Castle Gate A & D	4.0	46.1	45.2	8.7	.8	-	-	-	-	12,650	13,180	-	-	-
"	Hiawatha	King		Hiawatha	5.0	46.5	47.3	6.2	.6	-	-	-	-	13,710	13,690	-	-	-
"	"	"		"	4.3	47.5	47.5	2.0	.5	-	-	-	-	13,300	13,900	2,100	-	-
"	"	"		"	5.6	46.4	48.6	5.0	.5	-	-	-	-	13,070	13,850	-	-	-
"	"	"		"	6.5	46.7	48.2	5.1	.5	-	-	-	-	12,920	13,820	2,190	-	-
"	Price	Gordon Creek No. 01		Castle Gate A	8.3	46.1	48.2	5.7	.6	-	-	-	-	12,290	13,400	-	-	-
"	Scofield	Columbine		Castle Gate B	6.4	45.1	48.3	6.6	.6	-	-	-	-	12,373	13,160	2,150	-	-
"	"	"		"	5.6	46.3	47.7	6.0	.5	-	-	-	-	12,620	13,371	2,330	-	-
"	"	"		"	7.2	45.6	47.7	6.9	.5	-	-	-	-	12,220	13,170	2,415	-	-
"	Wattis	Star Point No. 01		Hiawatha	7.0	44.2	47.3	8.5	.6	-	-	-	-	12,100	13,010	2,720	-	-
"	"	"		"	7.1	44.0	46.9	9.1	.6	-	-	-	-	11,970	12,890	2,500	-	-
Iron	Cedar City	Webster		Uncor-related	5.9	41.9	40.5	17.6	6.4	-	-	-	-	10,490	11,100	2,180	2-1/2	54
Carbon	Castle Gate	Kenilworth Prep. Plant		Various	4.6	46.5	48.1	5.4	.6	-	-	-	-	12,810	13,440	2,130	-	-
"	"	"		"	3.6	46.3	47.7	6.0	.5	-	-	-	-	13,130	13,620	2,130	-	-
"	"	"		"	4.4	44.8	46.9	8.3	.5	-	-	-	-	12,610	13,190	2,160	-	-
"	"	"		"	5.4	44.5	46.3	9.2	.5	-	-	-	-	12,340	13,040	2,020	2	-
"	Helper	Carbon Fuel		Castle Gate B	3.4	45.8	47.9	6.3	.5	-	-	-	-	13,040	13,500	2,220	-	-
"	"	Spring Canyon Tipple		Castle Gate A & B	4.7	46.0	45.7	8.3	.8	-		-	-	12,610	13,230	2,150	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
UTAH (continued)																		
Carbon	Hiawatha	King		Hiawatha	4.7	46.0	47.1	6.9	.5	-	-	-	-	12,890	13,530	2,240	-	-
"	"	"		"	6.8	45.5	47.8	7.7	.5	-	-	-	-	12,770	13,790	2,[illegible]	1	-
"	"	"		"	5.7	46.2	46.2	7.6	.5	-	-	-	-	12,800	13,[illegible]	2,[illegible]	-	-
"	Castle Gate	Kenilworth Prep. plant (Castle Gate)		Castle Gate C	4.3	44.1	47.0	8.9	.5	6.2	74.7	1.3	9.7	12,[illegible]	13,[illegible]	2,[illegible]	2 1/2	48
"	"	Kenilworth Prep. plant (Clear Creek)		Castle Gate A	9.3	45.8	48.6	5.6	.5	-	-	-	-	12,070	13,310	2,160	1	50
"	"	"		"	8.5	46.3	48.5	5.2	.5	-	-	-	-	12,240	13,[illegible]	2,160	-	-
"	"	Kenilworth Prep. plant (Kenilworth)		Castle Gate D	4.9	44.6	47.8	7.6	.4	-	-	-	-	-	-	-	-	-
"	"	"		"	3.1	44.8	4[illegible]	7.1	.4	5.4	75.3	1.4	10.4	12,970	13,410	2,180	-	-
"	"	Kenilworth Prep. plant (Kenilworth & Clear Creek)		Castle Gate A & D	3.2	44.0	48.[illegible]	7.7	.5	-	-	-	-	12,900	13,330	2,[illegible]	-	-
"	"	"		"	4.9	45.1	48.1	6.8	.5	-	-	-	-	12,780	13,350	2,190	-	-
"	"	"		"	6.2	45.8	47.9	6.3	.5	-	-	-	-	12,[illegible]	13,490	2,[illegible]	-	-
"	"	"		"	8.1	44.8	48.7	6.5	.5	-	-	-	-	12,310	13,420	2,[illegible]	[illegible]	-
"	"	Kenilworth Prep. plant			4.1	44.2	47.6	[illegible]	.3	-	-	-	-	12,740	13,310	2,300	-	-
"	Helper	Carbon Fuel		Castle Gate B	5.0	46.3	47.1	6.6	.3	-	-	-	-	12,[illegible]	13,530	2,[illegible]	2 1/2	-
"	"	"		"	5.0	46.1	47.1	6.8	.3	-	-	-	-	12,[illegible]	13,[illegible]	-	-	-
"	"	Spring Canyon Tipple		Castle Gate A & B	3.7	47.7	45.0	7.3	.5	-	-	-	-	13,040	13,540	2,130	-	-
"	"	"		"	3.6	47.9	44.2	7.9	.5	-	-	-	-	12,970	13,460	2,190	-	-
"	"	"		"	4.8	45.3	46.[illegible]	8.1	.4	-	-	-	-	12,790	13,[illegible]	2,440	-	-
"	"	"		"	4.6	47.2	45.2	7.6	.5	-	-	-	-	12,[illegible]	13,[illegible]	2,190	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Type of sample	Bed	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Proximate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Helper	Spring Canyon Tipple		Castle Gate A & B	4.0	47.1	44.8	7.9	.6	-	-	-	-	11,800	13,[illegible]	2,190	-	-
"	"	"		"	5.2*	46.8	45.0	8.2	.6	-	-	-	-	12,490	13,240	2,280	1 1/2	-
"	Scofield	Columbine		Castle Gate B	5.9	44.6	46.3	8.5	.6	-	-	-	-	12,160	12,920	-	-	-
Emery	Hiawatha	Co-op		Hiawatha	3.6	46.4	46.1	7.5	.4	-	-	-	-	12,190	13,480	2,110	-	-
Carbon	Hiawatha	King			6.2	45.3	48.1	5.9	.6	-	-	-	-	12,520	13,470	2,100	-	-
"	"	"			5.7	45.1	49.0	5.1	.7	-	-	-	-	12,330	13,710	2,410	-	-
"	"	"			5.0	46.0	47.4	6.6	.6	-	-	-	-	12,920	13,[illegible]	2,150	-	-
"	"	"			6.4	45.6	49.2	5.2	.7	-	-	-	-	12,[illegible]	13,710	2,380	-	-
"	"	"			6.3	46.0	48.0	6.0	.6	-	-	-	-	12,820	13,680	2,210	3	-
"	"	"			6.3	45.8	48.2	6.0	.6	-	-	-	-	12,800	13,660	2,290	-	-
"	"	"			6.5	45.6	49.7	4.7	.7	-	-	-	-	12,940	13,840	2,320	3	-
"	Rains	Western			3.8	46.6	43.9	9.5	.4	-	-	-	-	12,[illegible]	13,[illegible]	-	-	-
"	Scofield	Columbine		Castle Gate B	6.9	45.1	48.3	6.6	.6	5.3	73.7	1.1	12.5	12,290	13,160	2,130	-	-
"	"	"		"	5.5	45.5	48.2	6.3	.5	-	-	-	-	12,440	13,300	2,290	1 1/2	-
"	"	"		"	5.6	45.3	45.4	5.5	.5	-	-	-	-	12,710	13,460	2,370	-	-
"	"	"		"	7.1	45.5	48.0	6.5	.6	-	-	-	-	12,140	13,280	2,350	-	-
"	"	"		"	8.3	44.7	46.6	8.7	.7	-	-	-	-	11,550	12,590	2,240	1 1/2	-
"	Wellington	Soldier Canyon		Rock Canyon	4.6	42.0	49.4	8.6	.5	-	-	-	-	12,450	13,050	2,430	-	-
"	"	"		"	5.6	40.4	51.6	8.0	.4	5.1	73.6	1.5	10.4	12,960	13,[illegible]	2,440	1 1/2	43
Emery	Wellington	American		Bliss Canyon	4.9	45.6	46.5	7.9	.9	-	-	-	-	12,510	13,570	2,050	-	47
"	"	"		"	4.5	46.5	45.4	8.1	.4	-	-	-	-	12,580	13,540	2,350	-	-
"	"	"		"	6.4	45.7	41.6	7.7	.4	5.[illegible]	75.8	1.5	9.7	12,[illegible]	13,720	2,130	1 1/2	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Castle Gate	Castle Gate Prep. plant		Castle Gate C,D & B	4.3	43.7	48.2	8.1	.5	-	-	-	-	12,740	13,310	2,180	-	47
"	"	"		"	5.2	44.1	49.4	6.3	.5	-	-	-	-	12,780	13,490	2,240	1 1/2	-
"	Helper	Carbon Fuel		Castle Gate B	3.7	44.3	50.5	5.2	.4	-	-	-	-	13,190	13,690	2,240	-	-
"	"	"		"	3.8	44.4	50.8	4.8	.4	-	-	-	-	13,320	13,840	2,230	-	-
"	"	"		"	3.7	44.5	48.4	7.1	.3	-	-	-	-	12,900	13,390	2,240	-	-
"	"	"		"	4.4	45.0	48.0	7.0	.3	-	-	-	-	12,800	13,400	2,300	-	-
"	"	"		"	4.3	45.2	48.2	6.6	.4	-	-	-	-	12,950	13,520	2,240	-	-
"	"	"		"	5.7	46.1	48.2	5.7	.4	-	-	-	-	12,820	13,590	2,230	1 1/2	-
"	Hiawatha	King			5.4	45.4	47.2	7.4	.6	-	-	-	-	12,730	13,470	2,230	-	-
"	"	"			4.4	45.4	47.7	6.9	.6	-	-	-	-	13,010	13,630	2,270	-	-
"	Kenilworth	Kenilworth		Castle Gate D	4.4	43.4	48.7	7.9	.4	-	-	-	-	12,690	13,290	2,240	-	-
"	Rains	Western			3.0	48.7	45.3	6.0	1.1	-	-	-	-	13,400	13,820	2,180	-	-
"	"	"			3.2	46.6	49.0	4.4	.6	-	-	-	-	13,460	13,900	-	-	-
"	"	"			2.9	46.1	46.9	7.0	1.0	-	-	-	-	13,100	13,500	2,150	-	-
"	Wellington	Knight-Ideal No. 2		Gilson	4.5	41.3	54.4	4.3	.4	-	-	-	-	13,290	13,910	2,170	-	-
"	"	"		"	5.1	40.5	54.3	5.2	.4	-	-	-	-	13,010	13,710	2,150	-	-
"	"	"		"	4.9	40.9	53.7	5.4	.4	-	-	-	-	13,070	13,740	2,180	-	-
"	"	"		"	5.0	40.8	53.8	5.4	.4	-	-	-	-	13,040	13,720	2,180	-	-
"	"	"		"	5.5	41.1	52.9	6.0	.4	-	-	-	-	12,880	13,640	2,190	-	-
"	"	"		"	6.7	41.2	53.5	5.3	.4	-	-	-	-	12,810	13,730	2,180	2	-
Emery	Columbia	Book Cliffs		Lower Sunnyside	6.7	40.0	52.8	7.2	.7	-	-	-	-	12,500	13,410	2,480	-	-
"	"	"		"	6.3	40.4	52.4	7.2	.7	-	-	-	-	12,580	13,440	2,370	-	-
"	"	"		"	3.8	40.1	53.0	6.9	.7	-	-	-	-	12,950	13,470	2,430	-	-
"	"	"		"	5.9	40.2	53.0	6.8	.7	-	-	-	-	12,680	13,480	2,430	-	-
"	"	"		"	5.8	40.4	52.8	6.8	.6	-	-	-	-	12,690	13,490	2,420	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %							
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
UTAH (continued)																		
Carbon	Helper	Carbon Fuel		Castle Gate B	6.2	43.4	45.9	10.7	.6	-	-	-	-	12,120	[illegible]	[illegible]	5-1/2(1)	-
"	Hiawatha	King		Hiawatha	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"		"	6.4	45.7	48.1	6.2	.7	-	-	-	-	12,730	[illegible]	[illegible]	-	-
"	"	"		"	5.8	45.1	49.0	5.9	.6	-	-	-	-	12,790	13,580	2,240	-	-
"	Price	Gordon Creek No.2		Castle Gate A	5.3	46.7	45.3	8.0	.5	5.4	73.4	1.5	11.1	12,580	[illegible]	2,400	-	43
"	"	"		"	6.0	46.5	45.1	8.4	.6	-	-	-	-	12,460	13,250	[illegible]	[illegible]	-
"	Wattis	Star Point No. 01		Various	6.0	43.0	44.6	12.4	.7	-	-	-	-	11,670	12,425	[illegible]	-	-
"	"	"		Hiawatha	5.5	43.4	46.6	10.0	.6	-	-	-	-	12,210	[illegible]	-	-	-
"	"	"		"	5.9	41.9	[illegible]	[illegible]	.7	-	-	-	-	11,370	[illegible]	[illegible]	-	-
Emery	Emery	Browning		Ferron J	4.1	40.7	52.3	7.0	.4	5.2	75.5	1.4	10.5	12,740	13,310	2,130	1-1/2	40
"	Huntington	Deer Creek		Blind Canyon	8.0	45.3	47.5	7.1	.5	5.6	75.2	1.3	10.1	12,450	13,530	2,110	3-1/2	45
"	"	"		"	5.6	44.6	47.1	8.3	.5	-	-	-	-	12,630	13,370	2,110	-	-
Carbon	Helper	Carbon Fuel		Castle Gate B	5.7	43.5	46.8	9.7	.5	-	-	-	-	12,310	13,070	2,320	-	-
"	Hiawatha	King		Hiawatha	5.1	45.1	48.1	[illegible]	[illegible]	-	-	-	-	12,700	13,520	2,340	-	-
"	Wattis	Star Point No. 01		"	4.4	42.6	45.8	11.6	.5	-	-	-	-	[illegible]	12,630	[illegible]	[illegible]	-
"	"	"		"	5.5	41.7	45.5	12.8	.6	-	-	-	-	[illegible]	12,410	[illegible]	-	-
"	"	"		"	6.6	42.0	46.6	12.0	.7	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	Clear Creek	O'Connor No. 2			[illegible]	44.2	49.5	5.9	.5	-	-	-	-	[illegible]	13,350	[illegible]	1	48
"	Helper	Carbon Fuel		Castle Gate B	2.9	[illegible]	[illegible]	[illegible]	.3	-	-	-	-	13,000	13,390	-	-	-
"	"	"		"	2.8	45.3	47.6	[illegible]	.3	-	-	-	-	13,280	13,460	[illegible]	-	-
"	"	"		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-
"	"	"		"	[illegible]	[illegible]	47.7	[illegible]	.3	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Proximate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Hiawatha	King		Castle Gate Sub No. 3	4.0	35.7	48.0	6.3	.6	-	-	-	-	13,090	13,7[illegible]	2,100	-	-
"	"	"		"	4.7	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	13,090	13,7[illegible]	2,1[illegible]	-	-
"	"	"		"	[illegible]	[illegible]	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	13,750	2,290	-	-
"	"	"		"	6.3	45.1	48.1	6.6	.6	-	-	-	-	12,740	13,610	2,250	-	-
"	Kenilworth	Kenilworth		Castle Gate D	4.1	43.9	49.0	7.1	.4	-	-	-	-	12,8[illegible]	13,3[illegible]	[illegible]	-	-
"	"	"		"	4.5	43.6	48.8	7.8	.5	-	-	-	-	12,710	13,310	2,160	-	-
"	Rains	Western		Castle Gate No. 1	3.8	46.3	47.8	5.3	.8	-	-	-	-	13,290	13,8[illegible]	-	-	-
"	"	"		"	4.3	47.0	47.1	5.7	.8	-	-	-	-	13,340	13,500	2,120	-	-
"	"	"		"	4.2	46.9	47.3	5.8	.7	-	-	-	-	13,140	13,7[illegible]	2,140	-	-
"	Wellington	Knight Ideal No. 2		Gilson	5.3	40.7	53.5	5.8	.5	-	-	-	-	12,860	13,580	2,1[illegible]	-	-
"	"	Soldier Canyon		Rock Canyon	5.6	40.7	52.0	7.3	.4	5.2	75.5	1.8	10.2	12,610	13,360	2,460	-	-
"	"	"		"	4.1	40.7	52.1	6.6	.4	-	-	-	-	12,730	13,310	2,330	-	-
Emery	Dragerton	Book Cliffs		Lower Sunnyside	5.0	40.6	52.8	6.7	.7	-	-	-	-	12,830	13,520	-	-	-
"	"	"		"	6.0	40.9	52.5	6.6	.7	-	-	-	-	12,710	13,530	[illegible]	-	-
"	"	"		"	6.0	40.9	53.0	6.1	.6	-	-	-	-	12,760	13,560	2,450	-	-
"	"	"		"	5.7	40.3	52.8	6.7	.7	-	-	-	-	12,780	13,510	2,410	7(1)	-
"	"	"		"	6.0	41.2	52.2	6.6	.6	-	-	-	-	12,660	13,480	2,460	7 1/2(1)	-
Carbon	Hiawatha	King			5.0	41.2	46.4	5.2	0.5	6.3	72.4	1.5	14.9	11,[illegible]	-	-	-	-
"	Lower Sunnyside	Columbia			4.1	37.8	53.8	6.0	1.0	5.7	73.3	1.5	12.7	13,[illegible]	-	-	-	-
"	"	"			7.4	38.1	52.4	5.1	1.0	5.6	77.2	1.5	11.6	13,860	-	-	-	-
"	"	Horse Canyon			[illegible]	[illegible]	[illegible]	[illegible]	.9	[illegible]	[illegible]	1.5	11.1	[illegible]	-	-	-	-
"	"	Sunnyside			1.4	[illegible]	[illegible]	5.1	1.2	[illegible]	[illegible]	[illegible]	11.1	-	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile	Proximate analysis, % Fixed carbon	Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Lower Sunnyside	Sunnyside			4.5	38.5	51.2	5.8	1.3	5.6	73.6	1.6	12.1	14,020	-	-	-	-
"	"	"			3.7	38.9	50.5	6.9	1.5	5.5	73.3	1.6	11.2	14,280	-	-	-	-
"	"	"			3.5	38.9	52.3	5.3	1.1	5.6	74.5	1.6	11.9	14,360	-	-	-	-
"	"	"			5.9	38.6	49.8	5.7	1.0	5.7	72.1	1.5	14.0	13,880	-	-	-	-
"	"	Unknown			4.9	38.3	49.7	7.1	.8	5.6	71.4	1.5	13.6	13,840	-	-	-	-
"	"	"			5.8	37.1	49.6	7.5	1.2	-	-	-	-	-	-	-	-	-
Emery	Blind Canyon	Unknown			5.5	44.6	44.8	5.1	.4	6.2	73.1	1.4	13.8	14,090	-	-	-	-
"	"	Horse Canyon			4.7	39.1	50.1	6.1	.8	5.6	72.6	1.6	13.3	13,820	-	-	-	-
"	Sunny-side	Coredirt			3.1	39.0	52.8	5.1	.8	5.6	75.4	1.4	11.7	14,280	-	-	-	-
Iron	Unknown	Unknown			14.3	34.7	45.7	5.3	5.0	5.4	57.0	1.0	26.3	10,620	-	-	-	-
San Pete	Mount Pleasant Coal Field	Unknown			3.0	45.2	45.5	6.3	.6	5.8	72.9	1.6	12.8	14,140	-	-	-	-
"	"	"			3.7	42.3	48.9	5.1	.8	5.8	73.2	1.6	12.9	14,050	-	-	-	-
"	"	"			3.1	43.0	45.5	8.4	.8	5.8	71.5	1.5	12.0	14,160	-	-	-	-
"	"	"			3.7	43.0	45.8	7.5	.7	-	-	-	-	14,090	-	-	-	-
"	"	"			3.2	42.9	45.3	8.6	.6	5.7	71.6	1.4	12.1	14,250	-	-	-	-
"	"	"			4.7	42.2	43.9	9.2	.5	5.8	69.6	1.4	13.5	13,850	-	-	-	-
Carbon	Castle Gate District	Carbon Fuel		Castle Gate B	4.5	45.8	47.3	6.9	0.3	5.5	74.7	1.4	11.9	12,870	13,480	2,250	-	54
"	"	Castle Gate		Castle Gate D	5.1	43.5	50.2	6.3	.2	5.6	73.9	1.3	13.4	12,850	13,540	2,290	-	45
"	"	Kenilworth		"	4.1	43.9	49.0	7.1	.4	5.3	76.1	1.3	12.0	12,820	13,380	2,180	-	43

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %							
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Castle Gate District	Panther		Castle Gate B	3.9	41.6	49.1	5.4	.5	5.7	71.9	1.4	15.1	13,020	13,540	2,110	-	-
"	"	Royal		Castle Gate D	3.2	43.2	49.5	7.3	.4	5.6	75.4	1.4	10.0	13,000	13,430	2,220	-	46
"	Gordon Creek District	Blue Blaze		Castle Gate A	6.1	44.9	48.0	7.1	.6	-	-	-	-	12,330	13,130	-	-	-
"	"	Gordon Creek		Hiawatha	12.6	43.6	51.8	4.6	.5	-	-	-	-	10,550	12,070	-	-	-
"	"	National		Castle Gate A	6.6	45.3	47.9	6.8	.6	-	-	-	-	12,200	13,060	2,470	-	-
"	"	Sweet		Hiawatha	5.8	45.5	48.0	6.5	.6	5.4	73.4	1.6	13.9	12,590	13,360	2,420	-	-
"	Hiawatha District	Hiawatha King No. 1		Hiawatha	6.1	45.9	48.6	5.5	0.5	6.1	70.0	1.3	15.0	12,920	13,770	2,048	-	46
"	"	Wattis		Wattis	7.1	44.3	48.4	7.3	.9	5.9	70.1	1.4	17.3	12,200	13,130	2,620	-	54
"	Pleasant Valley District	Clear Creek		Castle Gate A	9.6	44.2	51.1	4.7	.5	5.4	76.0	1.4	12.0	12,210	13,500	2,520	-	47
"	"	Columbine		Castle Gate B	6.8	45.0	49.3	5.7	.7	5.5	74.8	1.4	11.6	12,570	13,500	2,310	-	46
"	"	Kinney		Castle Gate A	8.1	41.4	44.9	5.6	.9	5.8	67.7	1.4	18.6	12,220	13,300	2,280	-	-
"	"	Winter Quarters		"	6.9	43.1	44.8	5.2	.7	6.0	69.1	1.4	17.6	12,470	13,400	2,130	-	-
"	"	Day		Spring Canyon	3.9	44.9	47.4	7.7	1.7	5.9	74.7	1.5	9.8	13,040	13,560	2,010	-	46
"	"	Liberty		"	4.9	45.5	46.6	7.9	.8	6.1	72.1	1.4	13.9	12,610	13,260	2,140	-	46
"	"	Peerless		"	3.6	44.2	49.4	6.4	.7	5.5	75.7	1.7	10.8	12,930	13,460	2,490	-	46
"	"	Rains		"	4.8	44.9	46.5	8.0	.6	5.5	72.2	1.3	14.9	12,590	13,230	2,210	-	-
"	"	Spring Canyon		Castle Gate D	4.1	45.7	47.3	6.0	.4	5.7	74.9	1.4	10.9	12,920	13,480	2,260	-	48

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu As received	Btu Dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
UTAH (continued)																		
Carbon	Pleasant Valley District	Standard		Spring Canyon	2.3	45.5	47.4	6.5	.6	7.0	72.9	1.0	13.8	13,480	13,200	2,190	-	-
"	"	Vulcan		"	5.1	46.3	46.3	7.4	1.6	5.9	74.2	1.6	9.9	12,690	13,370	2,040	-	47
"	"	Western		"	4.5	47.0	46.9	6.1	.7	5.7	74.6	1.6	9.7	13,040	13,670	2,080	-	-
Carbon	Sunnyside District	Columbia		Sunny-side	5.4	38.1	50.4	6.1	1.0	5.6	72.2	1.5	13.6	12,920	13,660	2,650	-	-
"	"	Sunnyside		"	5.8	38.4	50.2	5.6	1.0	5.8	72.7	1.5	13.4	13,080	13,890	2,820	-	-
Carbon	Upper Huntington Canyon	Larsen & Rigby		Castle Gate A	6.8	47.0	47.5	5.5	.7	5.8	67.5	1.3	20.3	12,490	13,410	2,200	-	-
"	"	New York		"	6.9	40.1	47.8	5.2	1.1	5.7	69.9	1.3	16.8	12,480	13,370	2,110	-	-
Carbon	Wellington District	Coal Creek		Gilson	5.7	40.1	51.2	8.7	.5	-	-	-	-	12,240	12,980	2,430	-	48
"	"	Knight Ideal No. 1		"	3.9	40.4	50.7	8.9	.4	5.2	75.4	1.4	11.5	12,460	12,970	2,350	-	44
"	"	Knight Ideal No. 2		"	5.1	40.7	54.1	5.2	.4	5.2	74.4	1.4	10.4	13,100	13,800	2,200	-	43
"	"	Rock Canyon		"	5.7	40.7	51.3	8.0	2.2	4.9	73.0	1.5	12.3	12,610	13,370	2,230	-	47
"	"	Soldier Canyon		Rock Canyon	4.3	40.7	52.5	6.8	.4	-	-	-	-	12,730	13,310	2,330	-	45
"	"	Star Point		Castle Gate A	6.4	42.3	52.9	4.8	.6	5.3	76.6	1.5	11.9	12,680	13,540	2,100	-	47
Emery	Emery District	Browning		Ferron I	6.1	42.4	49.6	8.0	.6	5.1	74.2	1.3	11.9	12,520	13,330	2,130	-	39
"	"	Sun Valley		Ferron A	7.5	41.3	47.8	10.9	.9	5.1	73.0	1.4	10.9	11,650	12,590	2,360	-	43
"	Hiawatha	Hiawatha Mohrland		Hiawatha	5.2	44.1	48.8	7.1	.7	6.2	69.7	1.5	15.5	12,658	13,351	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
UTAH (continued)																		
Emery	Huntington Canyon District	American		Blind Canyon	3.9	44.3	48.9	6.8	.4	-	-	-	-	13,090	13,630	2,160	-	48
"	"	Bear Canyon Co-op		Hiawatha	5.2	46.7	48.1	5.2	.5	6.0	77.9	1.5	9.9	13,180	13,910	2,130	-	52
"	"			Bear Canyon	5.4	44.1	49.7	6.2	.5	-	-	-	-	[illegible]	13,710	[illegible]	-	48
"	"	Deer Creek		Blind Canyon	4.7	44.9	46.9	8.2	.5	-	-	-	-	[illegible]	13,430	2,170	-	47
"	"	Lemmaster		Bear Canyon	6.8	45.6	50.0	4.4	.5	-	-	-	-	12,933	13,860	2,080	-	67
"	"	Paramount		Blind Canyon	5.3	42.8	50.7	6.5	1.0	5.8	75.9	1.5	10.7	12,850	13,560	2,390	-	48
Emery	Orangeville	Deseret		Hiawatha & Bear Canyon	5.7	45.0	48.7	6.3	.6	5.6	74.6	1.5	10.4	12,840	13,620	2,190	-	50
"	"	Oliphant		Hiawatha	5.3	40.9	52.4	6.7	.6	-	-	-	-	12,520	13,120	2,200	-	-
"	"	Hilberg		"	6.4	41.1	51.1	7.8	.5	5.4	72.6	1.5	11.8	12,280	13,120	2,320	-	46
Emery	Sunnyside	Book Cliffs		Sunnyside	5.3	40.9	52.4	6.7	.6	-	-	-	-	12,780	13,510	2,430	-	48
"	"	Horse Canyon		"	4.7	39.1	50.1	5.1	.8	5.6	72.6	1.6	13.1	12,880	13,520	2,370	-	-
Grand	Thompson	Sego		Chesterfield	8.0	35.7	45.9	10.4	.7	5.6	65.4	1.4	16.5	11,550	12,550	2,800	-	-
Sevier	Muddy Creek	Southern Utah Fuel		Upper Ivie	9.3	43.6	49.5	6.9	.4	-	-	-	-	11,670	12,850	2,110	-	50
"	Salina Canyon	Sevier Valley		Ivie	6.1	45.0	45.9	9.1	.6	5.3	71.4	1.3	12.3	12,030	12,840	2,210	-	48
San Pete	Wales	All Mines(7)		Wales	2.4	32.4	46.0	19.2	3.7	4.2	64.1	1.2	7.8	11,201	11,479	-	-	-
"	Sterling	Sterling		Sterling	3.1	42.6	43.2	6.1	.9	-	-	-	-	11,727	12,800	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									UTAH (continued)									
Uintah	Vernal	North Star			8.5	44.1	47.2	10.1	1.6	5.3	62.8	1.0	19.3	11,250	12,290	-	-	-
"	"	Wardell			5.3	37.3	48.0	17.7	1.9	-	-	-	-	10,450	11,380	2,710	-	46
Carbon	Consumers	Sweet	1947		8.1	45.7	49.1	5.2	0.5	5.4	77.[illegible]	1.6	13.9	12,160	13,230	2,570	-	-
"	"	"	1949		7.8	45.2	49.5	5.3	.5	-	-	-	-	12,490	13,540	-	-	-
"	"	"	1950		6.1	45.5	49.6	4.9	.6	-	-	-	-	12,850	13,680	-	-	-
"	"	"	1949		5.6	45.2	49.8	5.0	.5	-	-	-	-	12,750	13,510	-	-	-
"	"	"	1950		5.4	45.0	46.7	7.8	.5	-	-	-	-	12,440	13,150	-	-	-
"	"	"	1950		4.6	45.4	47.8	6.8	.7	-	-	-	-	12,730	13,340	-	-	-
"	"	"	1947		8.7	45.2	47.0	7.8	.5	-	-	-	-	11,590	12,700	2,630	-	-
"	"	"	1949		5.8	44.7	49.3	6.0	.6	-	-	-	-	12,510	13,280	2,960	-	-
"	"	"	1947		11.7	44.4	47.2	8.4	.6	-	-	-	-	10,960	12,410	2,420	-	-
"	"	"	1948		11.6	44.6	48.3	7.2	.5	-	-	-	-	10,830	12,250	2,420	-	-
"	"	"	1949		4.2	44.8	49.3	5.9	.5	-	-	-	-	12,540	13,100	-	-	-
"	"	"	1950		5.8	45.5	48.0	6.5	.6	-	-	-	-	12,590	13,360	2,420	-	-
"	Hiawatha	King	1948	King	5.2	43.5	49.0	7.5	.8	-	-	-	-	12,650	13,340	2,440	-	-
"	"	"	1949	Hiawatha	4.9	44.3	48.1	7.6	.7	-	-	-	-	12,650	13,000	2,450	-	-
"	"	"	1950	"	5.1	44.3	48.1	7.6	.6	-	-	-	-	12,640	13,320	2,360	-	-
"	"	"	1950	"	4.8	44.4	47.7	7.9	.6	-	-	-	-	12,760	13,420	-	-	-
"	"	"	1948	"	6.6	43.8	48.9	7.3	.7	-	-	-	-	12,500	13,380	2,390	-	-
"	"	"	1949	"	4.8	44.1	48.7	7.2	.7	-	-	-	-	12,680	13,320	2,400	-	-
"	"	"	1948	"	5.8	44.7	48.9	6.4	.6	-	-	-	-	12,710	13,490	2,490	-	-
"	"	"	1949	"	4.6	45.5	46.9	7.6	.6	-	-	-	-	12,680	13,290	2,280	-	-
"	"	"	1950	"	4.9	44.6	48.4	7.0	.6	-	-	-	-	12,710	13,370	-	-	-
"	Kenilworth	Kenilworth	1948	Kenilworth	3.0	44.2	48.2	7.6	.5	-	-	-	-	12,850	13,250	-	-	-
"	"	"	1949	"	3.0	44.2	49.1	6.7	.5	-	-	-	-	12,800	13,200	-	-	-
"	"	"	1948	"	3.1	44.3	49.2	6.5	.5	-	-	-	-	12,950	13,360	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
UTAH (continued)																		
Carbon	Latuda	Liberty	1948	Liberty Sub No. 1	3.8	46.6	47.4	6.0	.7	-	-	-	-	13,150	13,670	-	-	-
"	"	"	1948	"	4.9	45.5	46.6	7.9	.8	-	-	-	-	12,610	13,260	2,170	-	-
"	National	McKeown	1950	Castle Gate	5.3	46.2	48.5	5.3	.5	-	-	-	-	12,830	13,540	-	-	-
"	"	"	1950	"	5.9	46.9	46.6	6.5	.4	-	-	-	-	12,700	13,500	-	-	-
"	"	"	1950	"	4.5	46.1	46.5	7.4	.4	-	-	-	-	12,730	13,330	-	-	-
"	"	"	1950	"	6.1	44.9	48.0	7.1	.6	-	-	-	-	12,330	13,130	-	-	-
"	"	National	1950	[illegible] Creek	6.1	46.2	47.8	6.0	.6	-	-	-	-	12,600	13,480	-	-	-
"	"	"	1948	"	6.6	45.4	47.6	7.0	.5	-	-	-	-	12,190	13,050	2,660	-	-
"	"	"	1949	"	6.6	45.3	47.9	6.8	.6	-	-	-	-	12,200	13,060	-	-	-
"	"	"	1950	"	8.1	45.4	47.9	6.7	.6	-	-	-	-	12,260	13,360	2,470	-	-
"	Rains	Rains No. 2	1950		2.9	44.9	47.1	7.8	.5	-	-	-	-	12,990	13,320	-	-	-
"	Royal	Royal No. 2	1948	Castle Gate No. 2	2.8	45.2	45.1	9.7	.7	-	-	-	-	-	-	-	-	-
"	"	"	1950	"	2.4	45.6	48.4	6.0	.6	-	-	-	-	13,000	13,320	-	-	-
"	Scofield	Cox & Smith	1949	Castle Gate Upper bench	13.6	44.0	49.6	6.5	.5	-	-	-	-	10,700	12,390	2,270	-	-
"	"	"	1949	"	14.5	42.1	50.7	7.2	.5	-	-	-	-	10,250	11,990	1,230	-	-
"	Spring Canyon	Spring Canyon	1949	Castle Gate D	4.4	45.1	48.8	6.1	.5	-	-	-	-	12,910	13,500	-	-	-
"	"	"	1949		2.3	45.0	48.3	6.7	.4	-	-	-	-	[illegible]	13,400	2,500	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, F°	Free swelling index	Hardgrove grindability index
								UTAH (continued)										
Carbon	Spring Canyon	Spring Canyon	1950		3.7	44.9	48.6	6.5	.8	-	-	-	-	12,960	13,460	-	-	-
"	"	"	1950		3.7	44.9	48.0	7.1	.5	-	-	-	-	12,810	13,300	-	-	-
"	"	"	1948		4.3	45.1	47.1	7.8	.7	-	-	-	-	12,760	13,330	2,220	-	-
"	"	"	1949		3.1	45.1	48.6	6.3	.4	-	-	-	-	13,060	13,480	2,180	-	-
"	"	"	1950		3.0	44.8	48.7	6.5	.4	-	-	-	-	13,050	13,450	-	-	-
"	"	"	1947		5.5	45.6	46.5	7.9	.7	-	-	-	-	12,610	13,340	2,200	-	-
"	Standard-ville	Standard	1950		2.4	47.5	47.0	5.5	.9	-	-	-	-	13,530	13,860	-	-	-
"	"	"	1947		2.6	45.1	48.1	6.8	.6	-	-	-	-	13,050	13,390	-	-	-
"	"	"	1948		2.4	46.4	45.1	8.5	.9	-	-	-	-	12,950	13,270	-	-	-
"	"	"	1949		2.7	45.9	47.0	7.1	.9	-	-	-	-	13,160	13,530	-	-	-
"	"	"	1950		3.0	45.6	46.0	8.4	.9	-	-	-	-	12,980	13,380	-	-	-
"	"	"	1948		5.2	44.6	45.7	9.7	.9	-	-	-	-	12,430	13,120	2,230	-	-
"	"	"	1948		4.4	44.5	46.4	9.1	.8	-	-	-	-	12,530	13,110	2,200	-	-
"	"	"	1950		2.7	45.7	46.2	8.1	.8	-	-	-	-	12,970	13,330	2,160	-	-
"	"	"	1946		4.7	45.7	45.0	9.3	.8	-	-	-	-	12,520	13,140	2,190	-	-
"	Union	Gordon Creek	1948	No. 2 Sub	12.6	43.6	51.8	4.6	.5	-	-	-	-	10,550	12,070	-	-	-
"	Wattis	Wattis	1948		5.0	44.6	48.3	7.1	.9	-	-	-	-	12,620	13,280	2,620	-	-
"	"	"	1948		5.5	44.4	48.5	7.1	.7	-	-	-	-	12,440	13,160	-	-	-
"	"	"	1948		7.8	44.2	48.3	7.5	1.0	-	-	-	-	12,060	13,080	2,500	-	-
"	"	"	1950		6.1	44.0	48.9	7.1	1.0	-	-	-	-	12,370	13,170	-	-	-
"	"	"	1950		7.0	43.7	49.3	7.0	1.0	-	-	-	-	12,280	13,200	-	-	-
"	"	"	1948		7.4	43.3	49.7	7.0	1.1	-	-	-	-	12,330	13,320	2,470	-	-
"	"	"	1950		6.3	43.2	49.4	7.4	.9	-	-	-	-	12,330	13,160	2,910	-	-
"	Wellington	Coal Creek	1950	Aberdeen	4.0	40.7	50.9	8.4	.5	-	-	-	-	12,400	12,950	-	-	-
"	"	"	1950	"	4.6	40.7	51.6	7.7	.5	-	-	-	-	12,510	13,110	2,470	0	0

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
							UTAH (continued)											
Carbon	Wellington	Coal Creek	1949	Aberdeen	3.6	40.6	[illegible]	[illegible]	.5	-	-	-	-	12,[illegible]	13,020	-	-	-
"	"	"	[illegible]	"	[illegible]	41.1	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	[illegible]	"	3.3	40.[illegible]	[illegible]	[illegible]	.5	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1949	"	[illegible]	40.[illegible]	[illegible]	7.6	.5	-	-	-	-	[illegible]	13,090	2,490	-	-
"	"	"	1950	"	4.9	41.0	50.4	[illegible]	.5	-	-	-	-	12,[illegible]	12,960	2,[illegible]	-	-
"	"	"	1950	"	4.3	40.9	50.8	8.3	.5	-	-	-	-	[illegible]	12,980	2,[illegible]	-	-
							WASHINGTON											
King	Black Diamond	Franklin No. 10		No. 10	[illegible]	[illegible]	[illegible]	[illegible]	.6	-	-	-	-	11,[illegible]	11,720	[illegible]	-	-
"	"	"		"	[illegible]	[illegible]	40.4	[illegible]	.6	[illegible]	[illegible]	1.4	9.0	11,[illegible]	12,090	[illegible]	-	1
"	"	Rogers No. 2		Rogers	10.7	45.3	[illegible]	5.5	.6	5.5	73.0	1.9	11.5	11,[illegible]	13,050	2,180	-	-
"	"	"		"	14.4	[illegible]	50.1	[illegible]	.7	-	-	-	-	10,[illegible]	12,410	2,[illegible]	-	-
"	Ravensdale	Black Knight		Black Knight	17.1	[illegible]	[illegible]	11.5	.5	4.9	66.4	2.1	14.6	[illegible],670	11,660	2,390	-	-
Kittitas	Roslyn	Roslyn Prep. plant			5.3	35.1	46.1	15.8	.4	-	-	-	-	11,620	12,[illegible]	-	-	-
"	"	"			4.8	38.0	46.4	15.6	.3	-	-	-	-	11,720	12,[illegible]	-	-	-
"	"	"			[illegible]	[illegible]	[illegible]	16.0	.4	-	-	-	-	11,[illegible]	12,[illegible]	-	-	-
King	Black Diamond	Palmer Nos. 10 & 17	19[illegible]	Franklin Nos. 10 & 17	[illegible]	42.2	44.2	13.6	0.6	-	-	-	-	11,740	12,460	2,910	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	.6	-	-	-	-	11,[illegible]	12,190	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	11,[illegible]	12,[illegible]	2,910	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine			Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
									WASHINGTON (continued)									
King	Cumberland	Olson No. 1	1948		3.7	43.2	43.7	13.1	.8	-	-	-	-	12,160	12,620	2,880	-	-
"	"	Ravensdale No. 4	1949	Nos. 3, 3 1/2, 4	9.9	30.1	44.2	15.7	.8	-	-	-	-	10,450	11,600	2,850	-	-
Kittitas	Cle Elum	Ronald No. 2	1948	Big	3.2	36.9	44.8	18.3	.4	-	-	-	-	11,550	11,930	-	-	-
"	"	"	1948	"	4.5	38.4	46.4	15.2	.3	-	-	-	-	11,950	12,520	-	-	-
"	"	Russell-Gillett	1948	Roslyn	8.1	40.3	47.1	12.6	.4	-	-	-	-	-	-	-	-	-
"	"	"	1948	"	10.1	40.1	47.3	12.6	.4	-	-	-	-	11,150	12,410	-		-
"	Ronald	Ronald No. 4	1949	No. 6	2.6	37.0	47.1	15.9	.5	-	-	-	-	12,180	12,500	2,910	-	-
"	Roslyn	Roslyn No. 3	1950	Roslyn	2.9	40.5	48.9	10.6	.4	-	-	-	-	13,140	13,520	2,360	-	-
"	"	"	1948	"	6.9	39.9	47.5	12.6	.3	5.5	72.5	1.9	7.2	12,150	13,080	2,280	-	-
"	"	"	1950	"	2.7	39.3	48.9	11.8	.4	5.4	72.9	1.9	7.6	12,880	13,240	2,360	-	-
"	"	"	1950	"	4.9	38.9	48.5	12.6	.3	-	-	-	-	12,410	13,050	2,360	-	-
"	"	Roslyn No. 9	1950	"	3.4	40.5	48.3	11.2	.4	5.4	72.7	1.8	8.5	12,730	13,190	2,360	-	-
"	"	"	1948	"	7.2	39.9	46.8	13.3	.3	5.3	71.1	1.8	8.2	11,850	12,770	2,330	-	-
"	"	Roslyn Nos. 3 & 9	1949	"	4.2	40.0	46.9	13.1	0.4	-	-	-	-	12,310	12,850	-	-	-
"	"	"	1950		3.5	39.7	46.9	13.4	1.2	-	-	-	-	12,310	12,760	-	-	-
"	"	"	1948		2.9	40.5	47.7	11.8	.3	-	-	-	-	12,750	13,130	-	-	-
"	"	"	1950		3.0	39.9	47.7	12.4	.4	-	-	-	-	12,520	12,910	-	-	-
"	"	"	1949		2.6	40.9	48.1	11.0	.4	-	-	-	-	12,920	13,260	-	-	-
"	"	"	1948		3.3	41.3	46.0	12.7	.4	-	-	-	-	12,540	12,970	-	-	-
"	"	"	1949		7.1	39.4	47.5	13.1	.5	-	-	-	-	11,870	12,800	2,350	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Year of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera- ture, °F	Free swelling index	Hardgrove grindability index
WASHINGTON (continued)																		
Kittitas	Roslyn	Roslyn Nos. 3 & 9	1950		3.7	39.5	47.3	11.8	.4	-	-	-	-	12,190	12,670	-	-	-
"	"	"	1948		4.6	40.1	47.7	12.0	.4	-	-	-	-	12,480	13,080	-	-	-
"	"	"	1943		10.1	39.4	47.5	13.3	.4	-	-	-	-	10,940	12,470	-	-	-
"	"	"	1948		3.7	39.0	47.8	11.4	.4	-	-	-	-	12,350	12,830	2,360	-	-
"	"	"	1949		7.9	39.2	47.1	13.7	.4	-	-	-	-	11,710	12,710	2,390	-	-
"	"	"	1950		3.9	39.8	47.6	12.6	.4	-	-	-	-	12,570	13,080	2,340	-	-
Lewis	Centralia	[illegible]	[illegible]	[illegible]	29.6	44.9	41.0	15.1	.5	-	-	-	-	7,510	10,730	-	-	-
"	"	"	1948	"	30.6	46.1	40.3	18.6	1.1	-	-	-	-	7,540	10,870	-	-	-
"	"	"	1950	"	29.2	46.3	40.4	13.3	1.4	-	-	-	-	7,690	10,860	-	-	-
Pierce	Carbonado	Carbonado	1944		4.2	35.2	48.3	16.5	.5	-	-	-	-	11,990	12,450	-	-	-
"	Wilkeson	Wilkeson-Wingate	1948	No. 4	5.0	25.3	47.1	17.6	2.4	-	-	-	-	12,030	12,660	-	-	-
Thurston	Wilkeson	Tono-Bucoda	1944	"	21.2	42.1	41.4	16.3	.5	4.9	61.2	1.0	16.1	8,520	10,800	2,360	-	-
Whatcom	Bellingham	Belling-ham	1944	Belling-ham	5.7	35.3	45.2	16.6	.3	-	-	-	-	10,680	11,320	-	-	-
"	"	"	1948	"	5.8	36.0	43.8	10.2	.4	-	-	-	-	10,175	10,800	-	-	-
"	"	"	1951	"	6.4	40.1	40.0	19.9	.3	-	-	-	-	10,240	10,940	2,510	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Bed	Proximate analysis, % Moisture	Volatile	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									WYOMING[47,48,101,104]									
Campbell	Gillette	Wyodak		Roland	26.9	43.5	44.2	12.1	1.4	-	-	-	-	8,360	11,440	-	-	-
"	"	"		"	25.0	42.7	46.2	11.1	.9	-	-	-	-	8,540	11,380	-	-	-
"	"	"		"	26.4	39.0	46.0	14.1	1.4	-	-	-	-	8,130	11,050	-	-	-
Carbon	Hanna	Hanna No. 2		Hanna No. 2	11.9	45.5	46.5	8.0	.3	-	-	-	-	10,730	12,180	-	-	-
Crook	Aladdin	Stillwell			15.1	40.5	39.8	19.7	7.9	-	-	-	-	8,910	[illegible]	-	-	-
Fremont	Hudson	Hudson			16.7	42.4	53.0	4.6	.6	-	-	-	-	10,450	12,550	-	-	-
"	"	"			18.9	40.9	52.8	6.3	.7	-	-	-	-	10,000	12,330	-	-	-
"	"	"			22.3	38.1	51.2	10.7	.9	-	-	-	-	9,220	11,860	-	-	-
"	"	Indian			16.2	40.7	46.6	12.7	1.1	-	-	-	-	9,560	11,410	-	-	-
"	"	Popula			18.2	41.0	53.8	5.2	.5	-	-	-	-	10,130	12,380	-	-	-
"	"	"			16.0	41.0	53.6	4.5	.5	-	-	-	-	10,510	12,510	-	-	-
"	"	"			22.0	43.0	48.8	8.2	.7	-	-	-	-	9,410	12,070	-	-	-
"	"	"			20.1	40.1	48.1	11.8	.8	-	-	-	-	9,150	11,450	-	-	-
Hot Springs	Crosby	Big Horn		Gebo	17.8	38.8	52.3	8.9	[illegible]	-	-	-	-	10,080	12,260	-	-	-
"	"	"		"	17.4	39.2	52.4	8.4	.9	-	-	-	-	10,150	12,290	-	-	-
"	"	Gebo or Owl Creek		"	14.7	44.2	51.1	4.7	.6	-	-	-	-	11,160	13,080	-	-	-
"	"	"		"	11.0	[illegible]	51.8	[illegible]	.6	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"		"	17.3	39.0	[illegible]	6.3	.9	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"		"	16.7	[illegible]	54.6	[illegible]	.8	-	-	-	-	[illegible]	[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								WYOMING (continued)										
Lincoln	Diamondville	Diamondville No. 1		Kemmerer	5.4	42.4	52.0	5.6	.8	-	-	-	-	12,700	13,430	-	-	-
Lincoln	Kemmerer	Adaville			19.0	45.2	50.9	3.9	.6	-	-	-	-	10,300	12,720	-	-	-
"	"	Keystone No. 1		Adaville	18.5	45.2	50.7	4.1	.7	-	-	-	-	10,510	12,800	-	-	-
"	Sublet	Kemmerer No. 5		Willow Creek	2.7	38.2	56.3	5.5	.9	-	-	-	-	13,430	13,800	-	-	-
Sheridan	Dietz	[illegible] No. 7		Monarch	21.3	41.2	52.8	6.0	.6	-	-	-	-	9,580	12,170	-	-	-
"	"	"		"	19.6	42.6	52.3	5.1	.6	-	-	-	-	9,950	12,370	-	-	-
"	"	"		"	17.3	41.6	53.0	5.4	.7	-	-	-	-	10,270	12,420	-	-	-
"	"	"		"	18.5	40.9	55.1	4.0	.5	-	-	-	-	10,200	12,510	-	-	-
"	"	"		"	15.7	41.0	53.5	5.5	.7	-	-	-	-	10,280	12,190	-	-	-
"	"	"		"	51.9	42.0	52.3	5.7	.6	-	-	-	-	10,230	12,450	-	-	-
"	"	"		"	16.6	42.1	52.4	5.5	.7	-	-	-	-	10,280	12,330	-	-	-
"	"	"		"	21.6	41.5	50.4	5.6	.8	-	-	-	-	9,660	12,310	-	-	-
"	"	"		"	21.5	42.1	50.8	7.1	.7	-	-	-	-	9,440	12,030	-	-	-
"	"	"		"	19.8	41.7	49.4	7.5	.7	-	-	-	-	9,540	11,900	-	-	-
"	"	Acme		"	22.6	42.9	49.4	7.7	.9	-	-	-	-	9,320	12,040	-	-	-
"	"	"		"	23.2	47.9	46.7	5.4	.7	-	-	-	-	9,550	12,440	-	-	-
"	"	Carney		Carney	22.1	42.9	52.2	4.9	.6	-	-	-	-	9,640	12,330	-	-	-
"	"	"		"	21.8	44.7	50.5	4.8	.5	-	-	-	-	9,680	12,380	-	-	-
"	"	"		"	22.2	44.6	50.3	5.1	.5	-	-	-	-	9,650	12,420	-	-	-
"	"	"		"	22.0	45.4	49.8	4.8	.6	-	-	-	-	9,710	12,450	-	-	-
"	"	"		"	22.5	41.8	52.1	6.1	.5	-	-	-	-	9,690	12,500	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening tempera- ture,°F	Free swelling index	Hardgrove grindability index
		Name	Date of analy- sis		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
					Wyoming (continued)													
Sheridan	Dietz	Carney		Carney	22.5	43.8	52.1	4.1	.5	-	-	-	-	9,690	12,500	-	-	-
"	"	"		"	22.5	45.1	50.3	4.6	.5	-	-	-	-	9,600	12,390	-	-	-
"	"	"		"	21.9	45.7	49.4	4.9	.4	-	-	-	-	9,650	12,350	-	-	-
"	"	"		"	20.8	47.2	47.7	5.1	.6	-	-	-	-	9,860	12,350	-	-	-
"	"	"		"	22.4	42.7	52.6	4.7	.5	-	-	-	-	9,610	12,390	-	-	-
"	"	"		"	19.8	45.7	50.1	4.2	.6	-	-	-	-	9,980	12,450	-	-	-
"	"	"		"	22.5	45.0	49.8	5.2	.4	-	-	-	-	9,520	12,290	-	-	-
"	"	"		"	22.9	48.4	46.3	5.3	.6	-	-	-	-	9,580	12,300	-	-	-
"	"	"		"	22.6	43.8	45.1	11.1	.6	-	-	-	-	8,910	11,510	-	-	-
"	"	Dietz No. 7		Dietz No. 3	23.5	44.4	44.3	11.3	.8	-	-	-	-	8,770	11,460	-	-	-
"	"	Kool		Monarch	22.5	52.5	41.9	5.6	.5	-	-	-	-	9,600	12,340	-	-	-
"	"	"		"	18.6	44.1	50.5	5.4	.7	-	-	-	-	10,000	12,280	-	-	-
"	"	"		"	24.2	45.0	43.7	11.3	.9	-	-	-	-	8,720	11,510	-	-	-
"	"	Model		Carney	22.7	44.1	50.9	5.0	.4	-	-	-	-	9,550	12,350	-	-	-
"	"	Monarch		Monarch	21.2	43.6	50.8	5.6	.7	-	-	-	-	9,680	12,280	-	-	-
"	"	"		"	22.6	46.1	48.1	5.8	.8	-	-	-	-	9,740	12,580	-	-	-
"	"	"		"	20.4	44.0	50.1	5.0	.7	-	-	-	-	9,760	12,266	-	-	-
"	"	"		"	22.1	44.2	48.2	7.6	.8	-	-	-	-	9,500	12,200	-	-	-
"	"	Acme, Kool Dietz, Model Carney Monarch		Carney and Monarch	20.1	41.6	53.5	4.9	.8	-	-	-	-	9,840	12,310	-	-	-
"		"		"	19.8	45.2	49.9	4.9	.7	-	-	-	-	9,890	12,330	-	-	-
"		"		"	20.6	41.6	53.9	4.5	.6	-	-	-	-	9,850	12,400	-	-	-
"		"		"	20.9	41.1	53.8	5.1	.6	-	-	-	-	9,630	12,180	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Wyoming (continued)													
Sheridan		Acme, Kool Dietz, Model Carney Monarch		Carney and Monarch	20.5	41.5	53.4	5.1	.6	-	-	-	-	9,780	12,300	-	-	-
"		"		"	20.4	42.0	53.4	4.6	.7	-	-	-	-	9,870	12,400	-	-	-
"		"		"	22.8	40.1	52.3	7.6	.6	-	-	-	-	9,190	11,910	-	-	-
"		"		"	20.6	41.8	53.7	4.5	.6	-	-	-	-	9,900	12,470	-	-	-
"		"		"	20.5	42.5	53.0	4.5	.5	-	-	-	-	9,910	12,470	-	-	-
"		"		"	18.5	43.2	52.3	4.5	.7	-	-	-	-	10,040	[illegible]	-	-	-
"		"		"	21.7	43.7	51.4	4.9	.5	-	-	-	-	9,750	12,450	-	-	-
"		"		"	21.3	42.2	53.5	4.3	.5	-	-	-	-	9,790	12,390	-	-	-
"		"		"	21.7	41.8	53.7	4.5	.6	-	-	-	-	9,760	12,470	-	-	-
"		"		"	19.6	42.8	53.1	4.1	.6	-	-	-	-	10,096	12,547	-	-	-
"		"		"	20.0	42.2	53.3	4.5	.6	-	-	-	-	9,940	12,420	-	-	-
"		"		"	18.5	42.7	51.6	5.7	.6	-	-	-	-	9,980	12,250	-	-	-
"		"		"	21.8	41.5	52.5	6.0	.6	-	-	-	-	9,710	12,420	-	-	-
"		"		"	20.1	42.7	51.9	5.4	.8	-	-	-	-	9,840	12,320	-	-	-
"		"		"	20.6	42.1	53.1	4.8	.7	-	-	-	-	9,870	12,430	-	-	-
"		"		"	21.7	42.0	51.1	6.9	.5	-	-	-	-	9,800	11,880	-	-	-
"		"		"	20.1	42.6	51.8	5.6	.7	-	-	-	-	9,750	12,200	-	-	-
"		Acme, Carney Dietz and Monarch		"	15.5	40.1	53.5	6.4	.8	-	-	-	-	10,250	12,130	-	-	-
"		"		"	20.8	40.0	56.1	3.9	.5	-	-	-	-	9,840	12,430	-	-	-
"		"		"	19.5	42.6	53.4	4.0	.5	-	-	-	-	10,090	12,447	-	-	-
"		"		"	17.4	40.9	54.0	5.1	.7	-	-	-	-	10,271	12,360	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %							
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, F°	Free swelling index	Hardgrove grindability index
								Wyoming (continued)									
Sheridan		Acme, Carney Dietz and Monarch		Carney and Monarch	21.6	40.5	53.4	6.1	.8	-	-	-	-	9,710	12,390	-	-	-
"		Acme and Monarch		Monarch	20.2	41.4	53.9	4.7	.7	-	-	-	-	10,010	12,540	-	-	-
"		"		"	19.2	42.8	52.4	4.8	.5	-	-	-	-	10,060	12,450	-	-	-
"		"		"	17.5	40.0	54.8	5.2	.6	-	-	-	-	10,210	12,370	-	-	-
"		"		"	21.0	42.4	53.5	4.1	.7	-	-	-	-	9,920	12,560	-	-	-
"		"		"	20.5	39.3	55.4	5.3	.6	-	-	-	-	9,910	12,500	-	-	-
Sheridan	Sheridan	Acme & Monarch	1927-28	Monarch	17.8	41.2	53.7	5.1	.7	-	-	-	-	10,190	12,400	-	-	-
"	"	"	1927-28	"	20.0	41.2	53.6	5.2	.7	-	-	-	-	9,940	12,430	-	-	-
"	"	"	1928-29	"	19.8	42.0	53.0	5.0	.7	-	-	-	-	9,980	12,460	-	-	-
"	"	"	1926-27	"	19.7	41.9	52.4	5.7	.7	-	-	-	-	9,970	12,420	-	-	-
"	"	"	1927-28	"	20.7	40.9	53.4	5.7	.7	-	-	-	-	9,790	12,340	-	-	-
"	"	"	1928-29	"	21.7	41.1	53.1	5.8	.6	-	-	-	-	9,690	12,360	-	-	-
"	"	Black Diamond	1922-23	"	19.6	44.3	48.6	7.1	.6	-	-	-	-	9,580	11,920	-	-	-
Sweetwater	Rock Springs	Blairtown	1913-14	Rock Springs No. 1	7.9	43.6	52.5	3.9	.9	-	-	-	-	12,470	13,540	-	-	-
"	"	"	1914-15	"	7.4	42.1	52.0	5.9	.9	-	-	-	-	12,240	13,220	-	-	-
"	"	Lion (Mines)	1921-22	Rock Springs	11.0	41.4	53.3	5.3	1.2	-	-	-	-	11,460	12,900	-	-	-
"	"	"	1924-25	"	7.3	41.6	54.9	3.5	.9	-	-	-	-	12,680	13,670	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening tempera-ture, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analy-sis		Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
					Wyoming (continued)													
Sweet-water	Rock Springs	Lion (Minna)	1921-22	Rock Springs	7.0	41.3	53.3	5.4	.9	-	-	-	-	11,790	12,680	-	-	-
"	"	"	1926-27	"	7.6	41.3	54.2	4.5	1.1	-	-	-	-	12,440	13,460	-	-	-
"	"	"	1923-24	"	11.9	42.4	52.6	5.0	.9	-	-	-	-	11,460	13,010	-	-	-
"	"	"	1924-25	"	7.8	42.1	53.3	4.6	.9	-	-	-	-	12,260	13,300	-	-	-
"	"	"	1925-26	"	10.5	43.2	52.3	4.5	1.1	-	-	-	-	11,680	13,050	-	-	-
"	"	"	1926-27	"	7.8	41.6	53.5	4.9	1.1	-	-	-	-	12,330	13,370	-	-	-
"	"	"	1927-28	"	11.1	40.0	52.8	7.2	1.2	-	-	-	-	11,360	12,780	-	-	-
"	"	Union Pacific	1906-07	Rock Springs No. 7	11.6	41.2	54.9	3.9	.9	-	-	-	-	11,770	13,328	-	-	-
"	"	Copen-hagen	1928-29	Rock Springs No.	10.2	42.4	53.7	3.9	1.0	-	-	-	-	12,160	13,540	-	-	-
"	"	"	1928-29	"	10.2	41.5	53.0	5.5	1.1	-	-	-	-	11,950	13,310	-	-	-
"	"	Premier	1925-26	"	10.6	43.0	53.0	4.0	.9	-	-	-	-	11,930	13,340	-	-	-
"	"	"	1926-27	"	11.3	41.1	53.0	5.9	.9	-	-	-	-	12,050	13,400	-	-	-
"	"	"	1927-28	"	10.1	42.6	53.3	4.1	.9	-	-	-	-	11,760	13,080	-	-	-
"	"	"	1928-29	"	10.2	42.0	51.8	6.2	1.0	-	-	-	-	11,620	13,330	-	-	-
"	"	"	1924-25	"	12.8	42.8	52.6	4.6	1.3	-	-	-	-	11,900	[illegible]	-	-	-
"	"	"	1925-26	"	10.2	[illegible]	[illegible]	[illegible]	.9	-	-	-	-	11,550	[illegible]	-	-	-
"	"	"	1926-27	"	12.2	42.6	52.6	4.8	1.1	-	-	-	-	11,560	13,110	-	-	-
"	"	"	1927-28	"	11.8	41.8	53.8	5.4	1.2	-	-	-	-	11,630	13,030	-	-	-
"	"	"	1928-29	"	10.8	42.1	51.7	6.2	1.2	-	-	-	-	11,770	13,160	-	-	-
"	Superior	Super-ior No. 1	1920-21	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	11,770	[illegible]	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, F°	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Sweet-water	Superior	Superior No. 1	1922-23	Rock Springs No. 1	11.1	41.6	49.8	8.6	1.3	-	-	-	-	11,300	12,710	-	-	-
"	"	"	1919-20	"	11.9	42.7	49.7	7.6	1.2	-	-	-	-	11,340	12,870	-	-	-
"	"	"	1920-21	"	11.6	42.1	50.3	7.6	1.3	-	-	-	-	11,310	12,700	-	-	-
"	"	"	1921-22	"	9.5	41.5	50.3	8.2	1.3	-	-	-	-	11,510	12,720	-	-	-
"	Sweet-water	Sweet-water	1908-09	Rock Springs No. 7	8.6	42.1	52.0	5.0	1.2	-	-	-	-	12,180	13,330	-	-	-
Weston	Cambria	Antelope No. 1 & 7 & Jumbo	1905		8.9	40.1	37.1	22.8	4.4	-	-	-	-	10,000	10,980	-	-	-
Albany	Rock-River	Rock River		Un-named	18.3	30.1	36.7	14.9	.6	-	-	-	-	8,460	-	2,410	-	-
"	"	"		"	-	36.8	45.0	18.2	.7	4.5	59.7	1.1	15.8	10,350	-	-	-	-
"	"	"		"	-	45.0	55.0	-	.9	5.5	73.0	1.4	19.2	12,660	-	-	-	-
"	"	Rock Creek		"	20.5	29.3	37.0	13.2	.6	5.8	48.2	.9	31.3	8,480	-	2,510	-	-
"	"	"		"	-	36.8	46.6	16.6	.7	4.5	60.7	1.1	16.4	10,660	-	-	-	-
"	"	"		"	-	44.2	55.8	-	.8	5.3	72.7	1.3	19.9	12,780	-	-	-	-
"	"	J.F. White Prospect		"	17.6	33.8	40.3	8.3	1.4	6.0	54.2	.9	29.2	9,590	-	2,280	-	-
"	"	"		"	-	41.1	48.8	10.1	1.7	4.9	65.7	1.1	16.5	11,630	-	-	-	-
"	"	"		"	-	45.6	54.4	-	1.5	5.4	74.1	1.2	18.5	12,630	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
					Wyoming (continued)													
Big Horn	[illegible]	Rogers		Unnamed	14.9	33.4	37.0	14.7	1.8	5.7	53.3	1.0	24.5	9,510	-	-	-	-
"	"	Gapin		"	-	39.3	44.6	16.1	2.1	4.7	62.6	1.2	13.3	11,180	-	-	-	-
"	"	"		"	-	46.9	53.1	-	2.5	5.6	74.7	1.4	15.8	13,330	-	-	-	-
"	"	Flagstaff		"	16.5	34.3	38.0	11.2	2.1	6.0	58.9	1.1	24.7	9,740	-	2,180	-	-
"	"	"		"	-	41.0	45.6	13.4	2.5	5.0	65.7	1.3	12.1	11,650	-	-	-	-
"	"	"		"	-	47.4	52.6	-	2.9	5.7	75.9	1.5	14.0	13,470	-	-	-	-
Campbell	"	Hensley		Roland	27.0	34.2	29.1	9.7	1.4	-	-	-	-	8,260	-	2,1[illegible]	-	-
"	"	"		"	-	69.3	35.9	15.1	2.0	-	-	-	-	11,320	-	2,1[illegible]	-	-
"	"	Peerless		"	31.9	31.8	30.6	5.7	.4	-	-	-	-	7,900	-	2,170	-	-
"	"	"		"	31.1	30.4	31.9	6.6	.6	-	-	-	-	7,920	-	2,260	-	-
"	"	"		"	34.0	28.4	32.0	5.6	.4	-	-	-	-	7,620	-	2,420	-	-
"	"	"		"	32.6	31.4	29.6	6.4	.6	-	-	-	-	7,750	-	2,150	-	-
"	Gillette	"		"	36.9	27.6	30.9	4.6	.3	-	-	-	-	-	-	-	-	-
"	"	"		"	33.3	30.0	31.8	5.9	.5	6.8	45.7	.6	40.5	7,770	-	-	-	-
"	"	"		"	-	43.4	47.7	8.9	.8	4.7	68.5	1.0	16.1	11,650	-	-	-	-
"	"	"		"	-	47.7	52.3	-	.8	5.2	75.2	1.1	17.7	12,750	-	-	-	-
"	"	"		"	33.4	24.0	32.6	5.0	.5	-	-	-	-	8,000	-	2,220	-	-
"	"	"		"	-	43.5	49.0	7.5	.7	-	-	-	-	12,010	-	-	-	-
"	"	"		"	36.9	27.6	30.9	4.6	.3	-	-	-	-	-	-	-	-	-
"	"	"		"	31.6	29.2	33.3	5.9	.6	-	-	-	-	8,180	-	-	-	-
"	"	"		"	-	42.7	48.7	8.6	.9	-	-	-	-	11,960	-	-	-	-
"	"	"		"	32.9	28.0	34.3	4.8	.3	-	-	-	-	8,110	-	2,190	-	-
"	"	"		"	-	41.7	51.2	7.1	.5	-	-	-	-	12,080	-	-	-	-
"	"	"		Unnamed	30.8	30.1	33.9	5.0	.3	6.7	47.8	.7	39.5	8,120	-	2,180	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening temperature, F°	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
								Wyoming (continued)										
Campbell	Gillette	Peerless		Unnamed	-	43.8	49.0	7.2	.4	4.7	69.1	1.0	17.6	11,750	-	-	-	-
"	"	"		"	-	47.3	52.7	-	.4	5.1	74.5	1.1	18.9	12,660	-	-	-	-
"	"	Eveland		Roland	32.0	30.1	37.8	5.1	.5	-	-	-	-	8,010	-	2,320	-	-
"	"	"		"	-	44.3	48.2	7.5	.7	-	-	-	-	11,770	-	-	-	-
"	"	Campbell		Felix	32.8	31.2	29.4	6.6	.6	-	-	-	-	7,740	-	2,320	-	-
"	"	"		"	-	46.4	43.8	9.8	.9	-	-	-	-	11,520	-	-	-	-
"	"	Country Bank		Unnamed	31.0	30.5	28.4	10.1	1.4	-	-	-	-	7,240	-	2,090	-	-
"	"	"		"	-	44.2	41.1	14.7	2.1	-	-	-	-	10,490	-	-	-	-
Carbon	Arlington	Cottontail		"	21.2	28.7	34.6	15.7	.9	-	-	-	-	-	-	-	-	-
"	"	"		"	-	36.4	43.8	19.8	1.1	-	-	-	-	-	-	-	-	-
"	Hanna	Coal Gulch		"	26.0	30.1	37.8	6.1	1.0	-	-	-	-	8,350	-	-	-	-
"	"	Prospect		"	-	40.7	51.1	8.2	1.4	-	-	-	-	11,290	-	-	-	-
"	"	Cut Off			24.0	28.5	39.4	8.1	1.0	-	-	-	-	8,100	-	-	-	-
"	"	Gulch Prospect			-	37.5	51.8	10.7	1.3	-	-	-	-	10,650	-	-	-	-
"	"	Muddy Bridge			20.7	36.0	33.4	9.9	1.1	5.4	51.8	.7	31.1	8,720	-	-	-	-
"	"	"			-	45.4	42.1	12.5	1.4	4.0	65.4	1.9	15.8	10,990	-	-	-	-
"	"	Mine			-	51.8	48.2	-	1.6	4.5	44.7	1.0	18.2	12,460	-	-	-	-
"	"	"			25.0	46.7	20.8	7.5	.4	5.6	51.1	.7	34.7	8,420	-	-	-	-
"	"	Muddy Bridge Mine			-	62.4	27.6	10.0	.5	3.7	68.2	1.0	16.6	11,240	-	-	-	-
"	"	"			-	69.3	30.7	-	.6	4.1	75.8	1.1	18.4	12,490	-	-	-	-
"	"	Carbon No. 2		Carbon	8.3	39.9	42.3	9.5	.9	-	-	-	-	-	-	-	-	-
"	"	"		"	-	44.5	46.1	10.4	1.0	-	-	-	-	-	-	-	-	-
"	Carbon	Union Pacific		"	11.9	36.4	46.2	5.5	1.7	-	-	-	-	-	-	-	-	-
"	"	Prospect		"	-	41.3	52.4	6.3	1.9	-	-	-	-	-	-	-	-	-
"	"	"		"	13.2	35.7	43.6	7.5	1.4	-	-	-	-	-	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Type of operation	Seam	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, %: Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Wyoming (continued)													
Carbon	Carbon	Prospect		Carbon	-	[illegible]	[illegible]	[illegible]	1.6	-	-	-	-	-	-	-	-	-
"	"	Carbon No. [illegible]		"	[illegible]	[illegible]	[illegible]	9.2	[illegible]	-	-	-	-	-	-	-	-	-
"	"	"		"	-	42.5	47.3	10.2	1.3	-	-	-	-	-	-	-	-	-
"	"	"		"	11.8	33.8	44.1	[illegible]	1.2	-	-	-	-	-	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	11.6	1.4	-	-	-	-	-	-	-	-	-
"	"	Prospect		[illegible]	14.3	36.8	44.5	4.2	.5	-	-	-	-	-	-	-	-	-
"	"	"		"	-	43.1	51.9	5.0	.6	-	-	-	-	-	-	-	-	-
"	"	Abandoned		"	9.2	41.6	44.8	[illegible]	.7	-	-	-	-	-	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	.7	-	-	-	-	-	-	-	-	-
"	"	"		"	6.5	[illegible]	[illegible]	5.1	.6	-	-	-	-	-	-	-	-	-
"	"	"		"	-	43.1	49.1	[illegible]	.7	-	-	-	-	-	-	-	-	-
"	[illegible]	[illegible]		"	13.0	33.4	45.5	8.1	1.1	5.7	60.4	1.4	23.3	10,720	-	-	-	-
"	"	"		"	-	38.4	52.3	9.3	1.3	4.9	69.4	1.6	13.5	12,[illegible]	-	-	-	-
"	"	"		"	-	42.3	57.7	-	1.4	5.3	76.6	1.7	14.9	13,590	-	-	-	-
"	"	[illegible] Spring		"	10.8	36.0	46.3	6.9	2.3	4.8	62.8	1.3	20.9	[illegible]	-	-	-	-
"	"	"		"	-	40.4	51.8	7.8	2.5	5.1	70.4	1.6	17.6	12,570	-	-	-	-
"	"	"		"	-	43.8	56.2	-	2.7	5.7	76.3	1.9	13.6	13,640	-	-	-	-
"	Dixon	[illegible]		"	14.4	31.9	48.6	5.1	.6	5.8	62.4	.9	25.2	10,[illegible]	-	-	-	-
"	"	"		"	-	37.2	56.8	6.0	.6	4.9	72.8	1.0	14.7	12,600	-	-	-	-
"	"	"		"	-	39.6	60.4	-	.7	5.3	77.4	1.1	15.5	13,400	-	-	-	-
"	"	[illegible]		"	14.3	31.5	48.9	5.3	.5	5.6	[illegible]	[illegible]	[illegible]	10,[illegible]	-	-	-	-
"	"	"		"	-	37.1	[illegible]	[illegible]	.5	4.7	[illegible]	[illegible]	[illegible]	12,[illegible]	-	-	-	-
"	"	"		"	-	39.4	60.6	-	.5	5.2	75.2	1.1	17.9	13,[illegible]	-	-	-	-
"	"	"		"	15.2	32.4	48.5	[illegible]	.6	5.8	59.9	1.0	29.2	10,[illegible]	-	-	-	-
"	"	"		"	-	38.2	[illegible]	[illegible]	.7	4.8	[illegible]	1.3	[illegible]	12,[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	.7	5.2	[illegible]	1.3	[illegible]	12,[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
										Wyoming (continued)								
Carbon	Dixon	Martin		Unnamed	15.8	33.3	47.5	3.4	.6	5.9	62.0	1.1	27.0	10,770	-	-	-	-
"	"	"		"	-	39.5	56.4	4.1	.7	4.9	73.6	1.3	15.4	12,740	-	-	-	-
"	"	"		"	-	41.2	58.8	-	.7	5.1	76.8	1.4	16.0	13,290	-	-	-	-
"	"	Linde		"	16.1	29.0	38.6	16.3	.6	5.3	50.4	.9	26.5	8,880	-	-	-	-
"	"	"		"	-	34.6	46.0	19.4	.8	4.2	60.1	1.1	14.4	10,580	-	-	-	-
"	"	"		"	-	42.9	57.1	-	.9	5.2	74.6	1.3	18.0	13,130	-	-	-	-
"	Fort Steele	Petty		"	7.5	37.8	48.8	5.9	.9	5.3	67.6	1.8	18.5	11,940	-	-	-	-
"	"	"		"	-	40.9	52.7	6.4	.9	4.8	73.1	1.9	12.9	12,900	-	-	-	-
"	"	"		"	-	43.6	56.4	-	1.0	5.1	78.1	2.0	13.8	13,780	-	-	-	-
"	Hanna	Hanna No. 1		Hanna No. 1	9.6	42.7	40.4	7.3	.4	5.5	62.8	1.3	22.7	11,250	-	-	-	-
"	"	"		"	-	47.2	44.7	8.1	.4	4.9	69.5	1.5	15.6	12,440	-	-	-	-
"	"	"		"	-	51.4	48.6	-	.5	5.3	75.6	1.6	17.0	13,530	-	-	-	-
"	"	"		"	11.8	41.7	40.2	6.3	.4	5.8	62.5	1.0	24.0	11,070	-	-	-	-
"	"	"		"	-	47.2	45.7	7.1	.5	5.1	70.8	1.1	15.4	12,550	-	-	-	-
"	"	"		"	-	50.9	49.1	-	[illegible]	5.5	76.3	1.2	16.5	13,520	-	-	-	-
"	"	"		"	10.1	41.0	41.9	7.0	.5	5.5	62.7	1.3	23.0	11,300	-	-	-	-
"	"	"		"	-	45.6	46.6	7.8	.5	4.6	69.7	1.4	15.7	12,570	-	-	-	-
"	"	"		"	-	49.5	50.5	-	.6	5.3	75.6	1.3	17.0	13,630	-	-	-	-
"	"	Hanna No. 2		Hanna No. 2	11.5	42.6	39.3	6.6	.4	5.3	59.7	.9	27.1	10,880	-	-	-	-
"	"	"		"	-	48.1	44.4	7.5	.4	4.5	67.4	1.1	19.1	12,300	-	-	-	-
"	"	"		"	-	52.0	48.0	-	.5	4.9	72.8	1.2	20.6	13,300	-	-	-	-
"	"	"		"	12.0	35.9	44.9	6.2	.4	5.7	60.6	1.0	26.1	10,640	-	-	-	-
"	"	"		"	-	42.0	50.9	7.1	.4	5.0	68.8	1.1	17.6	12,080	-	-	-	-
"	"	"		"	-	45.2	54.8	-	.5	5.4	74.1	1.2	18.8	13,110	-	-	-	-

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Carbon	Hanna	Hanna No. 4		Hanna No. 2	11.2	40.6	44.1	4.1	.1	6.2	65.5	.9	22.9	11,460	-	2,510	-	
"	"	"		"	-	45.7	49.7	4.6	.3	5.4	74.1	1.0	14.6	12,310	-	-	-	-
"	"	"		"	-	47.9	52.1	-	.4	5.6	77.7	1.1	15.2	13,540	-	-	-	-
"	"	"		"	12.7	41.2	40.6	5.5	.5	6.0	61.8	1.1	25.1	11,300	-	2,410	-	-
"	"	"		"	-	47.2	46.6	6.2	.5	5.1	70.7	1.3	15.9	12,600	-	-	-	-
"	"	"		"	-	50.4	49.6	-	.6	5.6	75.5	1.4	16.9	13,450	-	-	-	-
"	"	F.D. McMillen		Unnamed	17.2	33.2	45.8	3.8	.8	6.2	59.6	1.4	28.4	10,400	-	2,340	-	-
"	"	"		"	-	40.1	55.3	4.6	1.0	5.3	71.8	1.7	15.7	12,560	-	-	-	-
"	"	"		"	-	42.1	57.9	-	1.0	5.5	75.2	1.7	16.6	13,160	-	-	-	-
"	"	J. Johnson		"	9.5	39.3	42.9	8.3	.5	6.0	62.4	1.1	21.7	11,160	-	2,290	-	-
"	"	"		"	-	43.4	47.4	9.2	.6	5.4	69.3	1.2	14.2	12,330	-	-	-	-
"	"	"		"	-	47.9	52.1	-	.6	6.0	76.5	1.4	15.5	13,600	-	-	-	-
"	"	Charles West		"	17.0	34.5	42.5	6.0	1.7	6.1	55.9	1.1	29.0	10,040	-	2,570	-	-
"	"	"		"	-	41.6	51.2	7.2	2.1	5.1	67.4	1.6	16.6	12,100	-	-	-	-
"	"	"		"	-	44.8	55.2	-	2.2	5.5	72.7	1.7	17.9	13,040	-	-	-	-
"	"	Coulter		"	15.3	33.6	45.4	5.7	2.3	6.3	57.0	1.6	27.4	10,250	-	-	-	-
"	"	"		"	-	39.7	53.6	6.7	2.7	5.1	67.3	1.9	16.3	12,100	-	-	-	-
"	"	"		"	-	42.6	57.4	-	2.9	5.6	72.2	2.1	17.3	12,970	-	-	-	-
"	Dana	Kronabell		"	13.9	36.2	45.7	4.2	.4	5.5	60.0	1.4	28.5	10,520	-	-	-	-
"	"	"		"	-	42.0	53.1	4.9	.4	4.5	69.7	1.6	18.9	12,220	-	-	-	-
"	"	"		"	-	44.2	55.8	-	.4	4.8	73.3	.7	19.9	12,840	-	-	-	-
"	"	"		"	17.3	34.0	43.8	4.9	.3	5.5	61.7	1.3	26.3	10,470	-	-	-	-
"	"	"		"	-	41.1	53.0	5.9	.4	4.8	75.3	1.5	17.1	12,160	-	-	-	-
"	"	"		"	-	43.7	56.3	-	.4	5.1	79.2	1.6	15.2	12,920	-	-	-	-
"	"	Penn-Wyoming		"	15.4	37.5	41.4	5.7	.3	5.5	63.7	1.3	25.1	9,140	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine		Seam	Proximate analysis, %				Ultimate analysis, %					Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
		Name	Date of analysis		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen					
					Wyoming (continued)													
Carbon	Iron	Penn-Wyoming		Unnamed	-	42.1	53.1	4.6	.3	4.3	66.0	1.6	23.2	11,190	-	-	-	-
"	"	"		"	-	44.3	55.7	-	.4	4.5	69.2	1.7	24.2	11,720	-	-	-	-
"	"	Miller		"	15.5	37.2	44.8	2.5	.8	5.6	58.9	1.4	29.9	10,520	-	-	-	-
"	"	"		"	-	42.8	53.0	4.2	.9	4.6	69.6	1.7	19.0	12,440	-	-	-	-
"	"	"		"	-	44.6	55.4	-	1.0	4.8	72.7	1.8	19.7	12,920	-	-	-	-
"	Medicine Bow	Clifton-Wissler		"	13.3	33.6	44.2	8.9	1.1	5.5	57.3	1.2	26.0	10,040	-	2,450	-	-
"	"	"		"	-	38.3	50.9	10.3	1.3	4.7	66.1	1.4	16.2	11,580	-	-	-	-
"	"	"		"	-	43.2	56.8	-	1.6	5.2	73.6	1.6	18.2	12,910	-	-	-	-
"	"	Nelson		"	16.8	33.4	46.6	3.2	.2	5.9	59.0	.8	30.0	10,320	-	2,450	-	-
"	"	"		"	-	40.2	56.0	3.8	.2	4.8	72.1	1.0	18.1	12,410	-	-	-	-
"	"	"		"	-	41.8	58.2	-	.3	5.0	74.3	1.0	18.8	12,900	-	-	-	-
"	Rawlins	Dillon		"	10.1	33.9	47.6	8.4	.5	5.2	63.8	1.3	20.8	11,010	-	-	-	-
"	"	"		"	-	37.7	52.9	9.4	.6	4.5	70.9	1.5	13.1	12,250	-	-	-	-
"	"	"		"	-	41.6	58.4	-	.6	5.0	78.3	1.6	14.5	13,520	-	-	-	-
"	"	Nebraska		"	19.2	36.5	41.5	3.8	.3	5.7	58.9	1.3	30.0	9,770	-	-	-	-
"	"	"		"	-	45.1	50.2	4.7	.4	4.5	72.9	1.7	15.8	12,030	-	-	-	-
"	"	"		"	-	47.3	52.7	-	.4	4.7	76.5	1.7	16.7	12,620	-	-	-	-
"	"	Robertson Opening			13.6	34.6	43.1	8.7	1.4	5.5	58.8	.9	24.7	10,340	11,987	-	-	-
"	"	"		"	-	40.0	49.9	10.7	1.7	4.7	68.1	1.0	14.4	11,970	-	-	-	-
"	"	"		"	-	44.5	55.5	-	1.9	5.2	76.7	1.2	16.0	13,310	-	-	-	-
"	Walcott	J. P. Ryan		"	11.4	33.8	51.7	3.1	.6	5.6	65.6	2.2	23.0	11,430	-	2,260	-	-
"	"	"		"	-	38.1	58.4	3.5	.7	4.9	73.9	2.4	14.6	12,900	-	-	-	-
"	"	"		"	-	39.5	60.5	-	.8	5.1	76.5	2.5	15.1	13,360	-	-	-	-
Converse	Big Muddy	Big Muddy		Upper Big Muddy	25.1	32.0	38.1	4.8	.7	6.3	52.8	1.2	34.2	8,970	-	2,240	-	-

Table D-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or area	Mine Name	Date of analysis	Seam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Btu per pound	[illegible]	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
Wyoming (continued)																		
Converse	Big Muddy	Big Muddy		Upper Big Muddy	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		Lower Big Muddy	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	Glenrock	[illegible]		Unnamed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	Glenrock No. 2		Glenrock	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	[illegible]		Unnamed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	[illegible]	[illegible]		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	Lost Spring	[illegible]		Unnamed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	[illegible]		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Ultimate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
Wyoming (continued)																		
Converse	Lost Spring	Rosin		Unnamed	-	42.8	57.2	-	1.7	5.1	73.4	1.1	18.7	12,540	-	-	-	-
Crook	Aladdin	Stillwell		"	17.8	37.6	39.5	5.1	5.6	5.9	55.7	.9	26.8	10,110	-	-	-	-
"	"	"		"	-	45.7	48.1	6.2	6.8	4.8	67.7	1.1	13.4	12,290	-	-	-	-
"	"	"		"	-	48.7	51.3	-	7.3	5.2	72.2	1.2	14.1	13,100	-	-	-	-
"	"	"		"	14.0	36.8	38.1	10.9	5.0	6.0	55.9	.9	21.3	10,330	-	-	-	-
"	"	"		"	-	42.8	44.5	12.7	5.8	5.2	65.1	1.0	10.2	12,020	-	-	-	-
"	"	"		"	-	49.0	51.0	-	6.6	5.9	74.6	1.1	11.8	13,770	-	-	-	-
"	Sundance	Belche		"	19.3	35.4	34.2	11.1	4.4	5.9	51.0	.8	26.8	9,200	-	2,150	-	-
"	"	"		"	-	43.8	42.5	13.7	5.4	4.7	63.1	.9	12.0	11,400	-	-	-	-
"	"	"		"	-	50.8	49.2	-	6.3	5.4	73.1	1.1	13.9	[illegible]	-	-	-	-
Fremont	Hudson	Hickey		"	23.1	33.1	39.6	4.2	.7	6.2	55.1	1.4	32.4	9,510	-	2,150	-	-
"	"	"		"	-	43.0	51.5	5.5	.9	4.8	71.7	1.8	15.3	12,360	-	-	-	-
"	"	"		"	-	45.5	54.5	-	1.0	5.0	75.8	1.9	16.3	13,080	-	-	-	-
"	"	Indian		"	21.3	32.8	42.7	3.2	.9	6.1	55.9	.8	33.1	9.780	-	-	-	-
"	"	"		"	-	41.7	54.3	4.0	1.1	4.8	71.0	1.0	18.1	12,420	-	-	-	-
"	"	"		"	-	43.4	56.6	-	1.2	5.0	74.0	1.0	18.8	12,940	-	-	-	-
"	"	"		"	21.1	31.4	41.7	5.8	.5	6.2	54.3	1.2	32.0	9,460	-	-	-	-
"	"	"		"	-	39.7	52.9	7.4	.6	4.9	68.9	1.5	16.7	11,990	-	-	-	-
"	"	"		"	-	42.9	57.1	-	.7	5.3	74.3	1.7	18.0	12,940	-	-	-	-
"	"	"		"	20.9	32.0	43.4	3.7	.5	6.2	56.7	1.2	31.7	9,780	-	2,240	-	-
"	"	"		"	-	40.4	54.9	4.7	.6	4.9	71.7	1.6	16.5	12,360	-	-	-	-
"	"	"		"	-	42.4	57.6	-	.6	5.2	75.2	1.6	17.4	12,970	-	-	-	-
"	"	McKinley		"	20.7	33.9	37.8	7.6	1.2	7.2	51.9	1.2	29.9	9,420	-	-	-	-
"	"	"		"	-	42.8	47.6	9.6	1.5	4.9	68.0	1.5	14.5	11,800	-	-	-	-
"	"	"		"	-	47.3	52.7	-	1.7	5.4	75.2	1.6	16.1	13,140	-	-	-	-

Table B-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Type of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									Wyoming (continued)									
Fremont	Hudson	Popoagie No. 2		Lander	24.6	21.7	40.1	4.2	.7	6.4	58.4	1.2	32.9	9,180	-	-	-	-
"	"	"		"	-	41.6	52.8	5.6	.9	5.2	71.6	1.6	15.1	12,130	-	-	-	-
"	"	"		"	-	44.1	55.9	-	.9	5.5	75.8	1.7	16.1	13,060	-	-	-	-
"	"	"		"	20.9	33.9	41.7	4.0	.8	6.2	57.1	1.3	32.0	9,930	-	-	-	-
"	"	"		"	-	41.7	54.3	3.8	.9	4.9	72.4	1.5	17.0	12,530	-	-	-	-
"	"	"		"	-	43.4	56.2	-	.8	5.1	75.2	1.6	17.7	13,030	-	-	-	-
"	"	Mitchell		Unnamed	19.5	34.7	39.6	6.2	.7	6.1	56.0	1.4	29.6	9,780	-	2,310	-	-
"	"	"		"	-	43.1	49.2	7.7	.8	4.5	69.5	1.7	15.3	11,110	-	-	-	-
"	"	"		"	-	46.7	53.3	-	1.0	5.0	75.1	1.8	16.5	13,130	-	-	-	-
"	"	"		"	18.8	32.7	38.2	10.3	1.0	5.9	52.4	1.3	29.4	9,170	-	-	-	-
"	"	"		"	-	39.7	47.2	13.1	1.2	4.6	64.8	1.4	15.7	11,290	-	-	-	-
"	"	"		"	-	45.8	54.2	-	1.4	5.4	74.7	1.6	16.9	13,000	-	-	-	-
"	Lander	Big Horn		"	21.2	35.9	38.3	4.6	.6	6.1	55.3	1.2	32.3	9,640	-	-	-	-
"	"	"		"	-	45.5	48.6	5.9	.7	4.7	70.1	1.5	17.1	12,240	-	-	-	-
"	"	"		"	-	48.3	51.7	-	.7	5.0	74.5	1.6	18.2	13,000	-	-	-	-
"	Liberty Bonglia	Speyer Prospect		"	21.6	44.3	28.0	4.1	.3	6.0	61.6	1.9	26.1	9,020	-	-	-	-
"	"	"		"	-	58.3	36.6	5.4	.9	4.8	70.1	1.1	17.6	11,810	-	-	-	-
"	"	"		"	-	61.3	38.7	-	.9	4.6	74.1	1.2	19.7	12,480	-	-	-	-
Hot Springs	Crosby	Crosby or Big Horn		Gebo	16.6	31.1	45.5	4.8	.6	6.0	60.6	1.1	26.9	10,670	-	-	-	-
"	"	"		"	-	39.7	54.5	5.8	.7	5.0	77.7	1.6	9.2	13,790	-	-	-	-
"	"	"		"	-	42.1	57.9	-	.8	5.3	77.2	1.7	15.0	13,570	-	-	-	-
"	"	"		"	15.5	32.8	46.9	4.9	.6	6.2	66.1	1.4	26.1	10,750	-	-	-	-
"	"	"		"	-	37.5	58.5	4.7	.7	5.0	73.1	1.6	13.9	12,940	-	-	-	-
"	"	"		"	-	41.8	58.2	-	.7	5.5	77.6	1.7	14.7	13,650	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Ultimate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
Wyoming (continued)																		
Hot Springs	Crosby	Crosby or Big Horn		Gebo	15.1	36.5	44.5	3.9	.6	6.1	63.2	1.4	24.8	11,160	-	-	-	-
"	"	"		"	-	43.0	52.4	4.6	.7	5.2	74.6	1.7	13.2	13,170	-	-	-	-
"	"	"		"	-	45.1	54.9	-	.7	5.5	78.2	1.8	13.8	13,810	-	-	-	-
"	"	"		"	14.7	33.6	48.1	3.6	.7	6.1	64.1	1.4	24.1	11,410	-	-	-	-
"	"	"		"	-	39.4	56.4	4.2	.8	5.3	75.1	1.7	12.9	13,380	-	-	-	-
"	"	"		"	-	41.2	58.8	-	.9	5.5	78.4	1.7	13.5	13,970	-	-	-	-
"	Gebo	Gebo		"	17.0	35.5	45.2	2.3	.4	6.0	62.2	1.2	28.0	10,990	-	-	-	-
"	"	"		"	-	42.8	54.4	2.8	.5	4.9	75.0	1.3	15.5	13,250	-	-	-	-
"	"	"		"	-	44.1	55.9	-	.5	5.1	77.2	1.4	15.8	13,630	-	-	-	-
"	"	"		"	15.9	33.0	47.4	3.7	.6	6.1	62.0	1.3	26.3	10,980	-	-	-	-
"	"	"		"	-	39.2	56.4	4.4	.7	5.1	73.7	1.5	14.6	13,050	-	-	-	-
"	"	"		"	-	41.1	58.9	-	.7	5.4	77.2	1.6	15.1	13,660	-	-	-	-
"	"	"		"	16.9	33.1	46.0	4.0	.6	6.1	61.5	1.3	26.6	10,800	-	-	-	-
"	"	"		"	-	39.8	55.3	4.9	.8	5.0	74.0	1.6	13.7	13,000	-	-	-	-
"	"	"		"	-	41.8	58.2	-	.8	5.3	77.8	1.7	14.4	13,660	-	-	-	-
"	"	"		"	14.5	36.1	45.0	4.2	.6	6.0	63.5	1.4	24.3	11,240	-	-	-	-
"	"	"		"	-	42.3	52.8	4.9	.7	5.2	74.2	1.6	13.4	13,140	-	-	-	-
"	"	"		"	-	44.7	55.3	-	.7	5.4	78.1	1.7	14.1	13,820	-	-	-	-
"	"	"		"	13.8	35.5	45.5	5.2	.6	5.7	64.4	1.3	22.8	11,210	-	-	-	-
"	"	"		"	-	41.2	52.8	6.0	.7	4.9	74.7	1.5	12.2	13,010	-	-	-	-
"	"	"		"	-	43.9	56.1	-	.7	5.2	79.5	1.6	13.0	13,810	-	-	-	-
"	"	"		"	12.9	34.5	46.9	5.7	.5	6.1	65.6	1.4	20.7	11,280	-	2,240	-	-
"	"	"		"	-	39.6	53.8	6.6	.6	5.3	71.9	1.6	14.0	12,950	-	-	-	-
"	"	"		"	-	42.4	57.6	-	.6	5.7	77.0	1.7	15.0	13,860	-	-	-	-
"	Kirby Lucerne	MacPherson		Unnamed	10.3	36.0	50.7	3.0	.6	5.7	66.1	1.4	23.2	11,440	-	2,160	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Hot Springs	Kirby Lucerne	Macpherson		Unnamed	-	39.7	56.9	3.4	.7	5.0	74.2	1.6	15.1	12,840	-	-	-	-
"	"	"		"	-	41.1	58.9	-	.7	5.2	76.8	1.7	15.6	13,280	-	-	-	-
"	"	Price & Jones		"	15.1	33.0	49.1	2.8	.5	6.0	62.5	1.0	27.2	11,210	-	-	-	-
"	"	"		"	-	39.1	57.4	3.5	.6	5.0	74.5	1.2	15.3	13,360	-	-	-	-
"	"	"		"	-	40.7	59.3	-	.6	5.2	77.1	1.3	15.8	13,830	-	-	-	-
"	"	Baker		"	12.1	32.6	49.2	6.1	.9	5.4	63.8	1.0	22.8	11,250	-	-	-	-
"	"	"		"	-	37.1	55.9	7.0	1.0	4.6	72.5	1.1	13.3	12,800	-	-	-	-
"	"	"		"	-	39.8	60.2	-	1.1	5.0	77.9	1.2	14.8	13,750	-	-	-	-
"	"	Crosby		"	10.5	32.2	51.9	5.4	.9	6.4	69.1	1.3	20.8	12,440	-	2,580	-	-
"	"	"		"	-	38.8	57.0	4.2	1.1	5.5	73.6	1.6	14.2	12,990	-	-	-	-
"	"	"		"	-	40.5	59.5	-	1.2	5.5	76.8	1.7	14.8	13,560	-	-	-	-
Hot Springs	Thermopolis	M & M		No. 2	10.4	35.5	41.9	12.2	1.3	5.5	60.4	1.2	19.4	10,540	-	2,030	-	-
"	"	"		"	-	39.6	46.7	13.6	1.4	4.7	67.4	1.3	11.5	11,770	-	-	-	-
"	"	"		"	-	45.8	54.2	-	1.6	5.6	78.0	1.5	13.3	13,620	-	-	-	-
"	"	"		"	11.1	36.4	43.8	8.5	1.7	5.7	61.9	1.2	21.0	11,070	-	2,440	-	-
"	"	"		"	-	41.1	49.4	9.5	1.9	5.0	69.7	1.4	12.5	12,480	-	-	-	-
"	"	"		"	-	45.4	54.6	-	2.2	5.5	77.1	1.5	13.7	13,790	-	-	-	-
Johnson	Buffalo	Mitchell		Unnamed	29.1	29.1	34.6	7.2	.4	6.5	44.6	.5	40.8	7,630	-	-	-	-
"	"	"		"	-	41.0	48.8	10.2	.6	4.7	62.9	.7	20.9	10,750	-	-	-	-
"	"	"		"	-	45.6	54.4	-	.6	5.2	70.0	.9	23.3	11,970	-	-	-	-
"	"	"		"	25.8	32.8	28.9	12.5	.6	6.0	42.7	.6	37.6	7,390	-	-	-	-
"	"	"		"	-	44.5	38.5	17.0	.9	4.2	58.5	.8	18.9	[illegible]	-	-	-	-
"	"	"		"	-	53.5	46.5	-	1.1	5.0	70.3	1.0	22.6	12,280	-	-	-	-
"	"	Moore		"	28.1	24.8	37.7	9.5	.7	6.4	41.5	.6	39.9	7,050	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Johnson	Buffalo	Murare		Ingured	-	41.3	45.5	13.2	1.0	4.6	60.9	.8	19.5	10,530	-	-	-	-
"	"	"		"	-	47.6	52.4	-	1.2	5.3	70.1	1.0	22.4	12,170	-	-	-	-
"	Caster	Pumpley		"	23.5	35.7	35.6	5.2	.5	6.5	51.2	.7	35.9	9,050	-	2,210	-	-
"	"	"		"	-	46.6	46.6	6.8	.6	5.1	67.0	.9	19.6	11,620	-	-	-	-
"	"	"		"	-	49.9	50.1	-	.7	5.5	71.8	1.0	21.0	12,690	-	-	-	-
"	"	Prospect		"	16.8	31.4	36.8	15.0	1.5	5.5	58.9	1.0	28.1	8,480	-	2,500	-	-
"	"	"		"	-	37.8	44.2	18.0	1.9	4.4	58.8	1.2	15.7	10,200	-	-	-	-
"	"	"		"	-	46.1	53.9	-	2.3	5.4	71.8	1.5	91.0	12,430	-	-	-	-
"	Hamilton	Surface Prospect		Healy	28.4	31.1	34.0	6.5	.7	6.4	46.2	.7	39.5	8,000	-	-	-	-
"	"	"		"	-	43.4	47.5	9.1	1.0	4.5	64.6	1.0	19.8	11,170	-	-	-	-
"	"	"		"	-	47.7	52.3	-	1.1	5.0	71.0	1.1	21.8	12,280	-	-	-	-
Lincoln	Cumberland	Cumberland No. 1		Kemmerer	6.8	39.8	47.4	6.0	.4	5.6	69.0	1.1	17.9	12,270	-	-	-	-
"	"	"		"	-	42.7	50.9	6.4	.5	5.2	74.0	1.2	12.7	13,160	-		-	-
"	"	"		"	-	45.6	54.4	-	.5	5.5	79.1	1.3	13.6	14,060	-	-	-	-
"	Diamondville	No. 1		"	5.1	40.5	49.8	4.6	.5	5.6	73.0	1.2	15.1	12,960	-	-	-	-
"	"	"		"	-	52.7	52.4	4.9	.5	5.3	76.9	1.2	11.2	13,660	-	-	-	-
"	"	"		"	-	44.9	55.1	-	.5	5.6	80.8	1.3	11.8	14,360	-	-	-	-
"	Elkol	Elkol		Elkol	21.5	35.3	40.4	2.8	.6	6.4	58.4	.8	41.0	10,260	-	2,400	-	-
"	"	"		"	-	44.9	51.5	3.6	.8	5.1	74.3	1.0	15.2	13,060	-	-	-	-
"	"	"		"	-	46.6	53.4	-	.8	5.3	77.1	1.0	15.8	13,550	-	-	-	-
"	"	"		"	20.6	35.1	39.8	4.5	.6	6.3	56.3	.8	30.5	10,100	-	2,180	-	-
"	"	"		"	-	44.2	50.2	5.6	.7	5.0	72.2	1.0	15.5	12,720	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Lincoln	Elkol	Elkol		Elkol	-	46.8	53.2	-	.8	5.3	76.5	1.0	16.4	13,470	-	-	-	-
"	"	"		"	21.0	35.1	40.7	3.2	.6	6.2	57.1	.9	32.0	9,900	-	2,420	-	-
"	"	"		"	-	44.4	51.6	4.0	.8	4.9	72.3	1.1	16.9	12,920	-	-	-	-
"	"	"		"	-	46.3	53.7	-	.8	5.1	75.3	1.2	17.6	13,080	-	-	-	-
"	"	"		"	20.8	35.4	40.6	3.2	.7	6.3	57.8	.9	31.1	10,080	-	2,300	-	-
"	"	"		"	-	44.6	51.3	4.1	.9	5.0	73.0	1.1	15.9	12,730	-	-	-	-
"	"	"		"	-	46.5	53.5	-	.9	5.2	76.1	1.2	16.6	13,270	-	-	-	-
"	"	"		"	21.2	34.1	41.8	2.9	.6	6.6	58.2	.9	30.8	10,060	-	2,180	-	-
"	"	"		"	-	43.3	53.0	3.7	.8	5.4	73.9	1.2	15.0	12,770	-	-	-	-
"	"	"		"	-	44.9	55.1	-	.8	5.6	76.7	1.2	15.7	13,650	-	-	-	-
"	Oakley	Sneddon No. 1		Spring Valley	6.7	33.5	42.3	17.5	.7	5.1	61.7	1.1	13.9	10,970	-	2,390	-	-
"	"	"		"	-	35.9	45.4	18.7	.7	4.6	66.1	1.1	8.8	11,650	-	-	-	-
"	"	"		"	-	44.2	55.8	-	.9	5.7	81.3	1.4	10.7	14,330	-	-	-	-
"	Frontier	Kemmerer No. 1		Lower or "A"	5.9	39.5	50.9	3.7	1.1	5.6	73.0	1.0	15.6	12,780	-	-	-	-
"	"	"		"	-	42.0	54.1	3.9	1.1	5.2	77.5	1.2	11.1	13,680	-	-	-	-
"	"	"		"	-	43.6	56.4	-	1.2	5.4	80.6	1.2	11.6	14,190	-	-	-	-
"	"	"		Kemmerer No. 1	5.9	37.6	49.0	7.5	1.4	5.3	68.5	1.2	16.2	12,370	-	-	-	-
"	"	"		"	-	39.9	52.1	8.0	1.5	4.9	72.8	1.1	11.7	13,140	-	-	-	-
"	"	"		"	-	43.4	56.6	-	1.6	5.4	79.1	1.2	12.7	14,280	-	-	-	-
"	"	"		"	5.7	37.7	51.3	5.3	1.4	5.5	70.6	1.0	16.2	12,480	-	2,060	-	-
"	"	"		"	-	40.0	54.4	5.6	1.5	5.1	74.8	1.1	11.9	13,330	14,135	-	-	-
"	"	"		"	-	42.4	57.6	-	1.6	5.4	79.3	1.1	12.6	14,130	-	-	-	-
"	"	"		"	6.3	39.0	51.2	3.5	.9	5.5	72.0	1.0	17.1	12,780	-	2,060	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Ash	Ultimate analysis, %*: Sulfur	Ultimate analysis, %*: Hydrogen	Ultimate analysis, %*: Carbon	Ultimate analysis, %*: Nitrogen	Ultimate analysis, %*: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
							Wyoming (continued)											
Lincoln	Frontier	Kemmerer No. 1		Kemmerer No. 1	-	41.7	51.5	3.8	1.0	5.2	76.4	1.3	12.1	13,640	-	-	-	-
"	"	"		"	-	43.3	56.7	-	1.0	5.4	79.8	1.1	12.7	14,170	-	-	-	-
"	"	"		"	5.6	37.4	47.5	9.5	1.9	5.5	67.4	.9	15.1	12,200	-	2,170	-	-
"	"	"		"	-	39.7	50.2	10.1	1.5	5.2	11.4	1.0	15.8	12,710	-	-	-	-
"	"	"		"	-	44.1	55.9	-	1.7	5.8	79.4	1.1	12.0	14,140	-	-	-	-
"	"	"		"	5.2	46.7	47.5	5.6	1.9	5.5	68.1	1.1	15.3	12,210	-	2,190	-	-
"	"	"		"	-	40.8	50.2	9.0	1.1	5.2	71.8	1.2	11.1	12,880	-	-	-	-
"	"	"		"	-	44.9	55.1	-	1.6	5.7	78.9	1.3	12.5	14,150	-	-	-	-
"	"	Willow Creek Prospect		Willow Creek	4.0	36.7	55.8	4.8	.8	5.2	76.0	1.3	11.9	13,500	-	-	-	-
"	"	"		"	-	37.7	57.3	5.0	.8	4.9	70.2	1.4	8.7	14,060	-	-	-	-
"	"	"		"	-	39.6	60.4	-	.8	5.2	83.3	1.4	9.3	14,790	-	-	-	-
"	"	"		Unnamed	6.5	38.5	51.4	3.6	1.8	5.3	70.6	1.5	17.7	12,640	-	-	-	-
"	"	"		"	-	40.9	55.3	3.8	1.9	4.9	75.8	1.1	12.5	13,630	-	-	-	-
"	"	"		"	-	42.5	57.5	-	2.0	5.1	78.8	1.1	11.0	14,170	-	-	-	-
"	"	"		"	15.1	37.1	45.3	2.5	2.8	6.3	60.0	1.1	28.1	10,630	-	1,900	-	-
"	"	"		"	-	45.3	51.6	3.1	2.4	5.2	73.3	1.3	14.7	12,970	-	-	-	-
"	"	"		"	-	46.7	53.3	-	2.5	5.4	75.6	1.3	15.2	13,380	-	-	-	-
"	Kemmerer	Fitzpatrick		Spring Valley	7.1	35.2	50.8	6.9	.4	5.5	70.8	1.3	15.3	12,470	-	2,390	-	-
"	"	"		"	-	37.3	54.7	7.4	.5	5.1	76.2	1.4	9.6	13,420	-	-	-	-
"	"	"		"	-	40.9	59.1	-	.5	5.5	82.1	1.5	10.4	14,490	-	-	-	-
"	Marna	Prospect		Unnamed	9.6	35.7	46.9	4.8	.3	5.5	66.9	1.3	21.2	12,060	-	-	-	-
"	"	"		"	-	42.8	51.9	5.3	.4	4.9	74.8	1.7	3.9	13,270	-	-	-	-
"	"	"		"	-	45.2	54.8	-	.4	5.2	78.2	1.8	14.5	14,310	-	-	-	-
"	Stanley	"		"	27.6	30.8	31.7	9.7	.9	5.7	43.5	1.1	40.1	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									Wyoming (continued)									
Lincoln	Stanley	Prospect		Unnamed	-	47.8	41.8	11.4	1.2	3.5	55.9	1.5	26.4	9,110	-	-	-	-
"	"	"		"	-	49.4	50.6	-	1.4	4.2	64.5	1.7	28.2	10,520	-	-	-	-
"	Sublet	Kemmerer No.6		Kemmerer	3.9	40.1	49.0	7.0	.6	5.5	72.3	1.2	13.5	12,800	-	-	-	-
"	"	"		"	-	41.7	51.0	7.3	.6	5.3	75.2	1.3	10.3	13,420	-	-	-	-
"	"	"		"	-	45.0	55.0	-	.7	5.7	81.0	1.1	11.2	14,470	-	-	-	-
"	"	"		"	3.9	40.3	48.4	7.4	.7	5.5	71.2	1.3	13.2	12,810	-	-	-	-
"	"	"		"	-	42.0	50.3	7.4	.8	5.3	74.8	1.4	10.0	13,460	-	-	-	-
"	"	"		"	-	45.5	54.5	-	.9	5.7	81.0	1.6	11.2	14,470	-	-	-	-
"	"	"		"	7.1	38.7	50.4	3.8	.5	5.7	71.8	1.3	16.9	12,750	-	2,250	-	-
"	"	"		"	-	41.6	54.3	4.1	.6	5.7	77.3	1.4	11.1	13,720	-	-	-	-
"	"	"		"	-	43.4	56.6	-	.6	5.5	80.6	1.5	11.8	14,310	-	-	-	-
"	"	"		"	6.3	39.5	49.3	4.9	.5	5.6	71.9	1.3	15.8	12,680	-	2,170	-	-
"	"	"		"	-	42.1	52.7	5.2	.5	5.3	76.8	1.4	10.8	13,530	-	-	-	-
"	"	"		"	-	44.5	55.5	-	.5	5.6	81.0	1.5	11.4	14,280	-	-	-	-
"	"	No. 5		Willow Creek or No. 5	3.6	38.4	52.5	5.5	1.0	5.3	74.5	1.3	12.4	13,310	-	-	-	-
"	"	"		"	-	39.9	54.4	5.7	1.0	5.1	77.2	1.6	9.6	13,810	-	-	-	-
"	"	"		"	-	42.3	57.7	-	1.1	5.4	81.9	1.6	10.2	14,640	-	-	-	-
"	"	"		"	3.8	37.1	52.9	6.2	.9	5.5	73.7	1.3	12.4	13,050	-	-	-	-
"	"	"		"	-	38.6	54.9	6.5	.9	5.2	76.6	1.4	9.4	13,560	-	-	-	-
"	"	"		"	-	41.2	58.8	-	1.0	5.6	81.9	1.5	10.0	14,490	-	-	-	-
"	[illegible]	Kemmerer No.4		Kemmerer No. 1	6.6	39.2	47.7	6.5	1.4	5.3	69.6	1.3	15.9	12,360	-	-	-	-
"	"	"		"	-	42.0	51.1	6.9	1.5	4.9	74.4	1.3	11.0	13,230	-	-	-	-
"	"	"		"	-	45.1	54.9	-	1.6	5.2	80.0	1.4	11.8	14,210	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Lincoln	Viola	Prospect		Unnamed	22.4	35.8	38.8	3.0	1.9	6.4	54.6	.3	33.2	9,460	-	-	-	-
"	"	"		"	-	46.1	50.0	3.9	2.4	5.0	70.1	1.2	17.2	12,430	-	-	-	-
"	"	"		"	-	47.9	52.1	-	2.5	5.2	73.2	1.2	17.9	12,920	-	-	-	-
"	"	"		Willow Creek	4.7	39.7	51.3	4.3	.5	5.3	71.5	1.1	17.3	12,690	-	-	-	-
"	"	"		"	-	37.6	57.7	4.7	.5	4.9	77.5	1.2	11.2	13,760	-	-	-	-
"	"	"		"	-	39.4	60.6	-	.5	5.1	81.3	1.3	11.8	14,430	-	-	-	-
Park	Cody	Cody		Unnamed	17.3	41.3	35.6	5.8	.4	5.6	59.7	.9	28.4	10,060	-	-	-	-
"	"	"		"	-	37.7	55.5	6.8	.4	4.5	71.5	1.2	16.0	12,160	-	-	-	-
"	"	"		"	-	40.6	59.4	-	.5	4.8	76.6	1.1	16.0	13,020	-	-	-	-
"	"	Allison		"	13.8	35.0	39.3	11.9	.6	5.4	57.8	1.0	28.1	9,270	-	-	-	-
"	"	"		"	-	40.6	45.6	13.8	.7	4.5	61.3	1.2	21.5	10,750	-	-	-	-
"	"	"		"	-	47.1	52.9	-	.9	5.2	71.1	1.4	21.4	12,470	-	-	-	-
"	Garland	Homeysett		"	13.3	29.2	50.8	6.7	.8	5.6	62.0	1.1	23.8	10,840	-	2,090	-	-
"	"	"		"	-	33.7	58.5	7.8	1.0	4.7	71.5	1.3	13.7	12,530	-	-	-	-
"	"	"		"	-	36.6	63.4	-	1.1	5.7	77.5	1.4	14.9	13,590	-	-	-	-
"	Meeteetse	Graybull or Erskine		"	15.0	32.5	41.7	10.8	1.1	5.7	55.4	1.1	25.9	9,930	-	-	-	-
"	"	"		"	-	38.3	48.9	12.8	1.3	4.7	65.2	1.1	14.7	11,680	-	-	-	-
"	"	"		"	-	43.8	56.2	-	1.4	5.4	74.8	1.5	16.9	13,390	-	-	-	-
"	"	Black Diamond		"	17.7	27.3	47.4	7.6	.2	5.4	57.1	.8	28.9	9,690	-	-	-	-
"	"	"		"	-	33.1	57.7	9.2	.2	4.1	69.3	1.0	16.2	11,770	-	-	-	-
"	"	"		"	-	36.5	63.5	-	.2	4.5	76.4	1.1	17.8	12,960	-	-	-	-
"	"	Orr		"	16.1	35.1	40.8	8.0	.5	5.9	54.1	.9	30.6	9,320	-	-	-	-
"	"	"		"	-	41.9	48.6	9.5	.6	4.9	64.5	1.1	19.4	11,110	-	-	-	-
"	"	"		"	-	46.3	53.7	-	.7	5.4	71.3	1.2	21.4	12,280	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Bed	[illegible]	[illegible]	[illegible]	Ash	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Btu as received	[illegible]	Ash softening temperature, °F	[illegible] Index	[illegible] grindability Index
					Wyoming (continued)													
Park	Wiley	West Wiley (Thompson)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	East Wiley		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
Sheridan	"	Acme No. 1		Carney	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	Acme	"		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	Acme No. [illegible]		Carney & Masters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, %: Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Sheridan	Acme	Acme No. 2		Carney & Masters	-	43.5	56.5	-	.5	5.3	73.2	1.3	19.6	12,610	-	-	-	-
•	•	•		•	24.7	31.8	39.8	3.7	.4	6.5	52.1	1.2	35.9	9,016	-	2,130	-	-
•	•	•		•	-	42.1	53.0	4.9	.5	5.0	69.4	1.6	18.6	11,960	-	-	-	-
•	•	•		•	-	44.3	55.7	-	.5	5.7	73.0	1.7	19.6	12,570	-	-	-	-
•	Carneyville	Model		Carney	25.9	29.4	37.8	6.9	.3	6.2	51.0	1.0	34.6	8,610	-	-	-	-
•	•	•		•	-	39.7	50.9	9.4	.5	4.5	68.[illegible]	1.4	15.4	11,620	-	-	-	-
•	•	•		•	-	43.8	56.2	-	.5	5.0	75.9	1.5	17.1	12,830	-	-	-	-
•	•	Carney No. 1		•	22.9	34.2	39.6	3.4	.4	6.0	55.9	1.0	34.3	9,430	-	-	-	-
•	•	•		•	-	44.3	51.2	4.5	.5	4.5	71.1	1.3	18.1	12,210	-	-	-	-
•	•	•		•	-	46.4	53.6	-	.5	4.7	74.4	1.4	19.0	12,780	-	-	-	-
•	•	•		•	21.5	35.4	39.0	4.4	.8	5.8	50.9	1.0	33.1	9,720	-	-	-	-
•	•	•		•	-	44.7	49.7	5.6	1.0	4.6	69.9	1.3	17.8	12,370	-	-	-	-
•	•	•		•	-	47.3	52.7	-	1.0	4.6	74.0	1.4	19.0	13,100	-	-	-	-
•	•	•		•	25.3	32.9	39.0	2.8	.3	3.6	53.5	1.1	36.0	9,160	-	2,150	-	-
•	•	•		•	-	44.1	52.2	3.7	.6	4.6	71.6	1.5	18.2	12,250	-	-	-	-
•	•	•		•	-	45.8	54.2	-	.5	4.8	74.3	1.5	18.9	12,720	-	-	-	-
•	•	•		•	25.3	30.7	40.3	3.7	.4	6.3	53.5	1.1	35.0	9,110	-	2,100	-	-
•	•	•		•	-	41.2	53.9	4.9	.6	4.7	71.6	1.5	16.7	12,200	-	-	-	-
•	•	•		•	-	43.3	56.7	-	.6	5.0	75.3	1.6	17.5	12,820	-	-	-	-
•	•	•		•	24.5	30.4	41.9	3.2	.3	6.2	53.7	1.0	35.6	9,160	-	-	-	-
•	•	•		•	-	40.2	55.5	4.3	.4	4.6	71.1	1.3	18.3	12,120	-	-	-	-
•	•	•		•	-	42.0	58.0	-	.4	4.8	74.3	1.4	19.1	12,670	-	-	-	-
•	•	Carney No. 2		•	25.8	29.8	41.2	3.2	.3	6.3	53.4	1.1	35.7	8,970	-	2,200	-	-
•	•	•		•	-	40.1	55.6	4.3	.4	4.7	72.0	1.5	17.1	12,090	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Sheridan	Carneyville	Carney No. 1		Carney	-	41.9	58.1	-	.4	4.9	75.1	1.6	17.6	12,410	-	-	-	-
"	"	"		"	24.7	30.[illegible]	40.6	[illegible]	.4	[illegible]	[illegible]	[illegible]	[illegible]	9,180	-	-	-	-
"	"	"		"	-	40.9	53.[illegible]	5.7	.5	4.7	[illegible]	1.4	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	43.1	56.9	-	.5	4.9	78.9	1.5	19.6	12,950	-	-	-	-
"	Dietz	Dietz No. 1		Dietz No. 1	24.7	[illegible]	[illegible]	4.[illegible]	.4	6.2	[illegible]	[illegible]	45.1	9,[illegible]	-	-	-	-
"	"	"		"	-	43.9	41.8	5.1	.5	4.[illegible]	68.6	1.4	18.[illegible]	11,[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	46.9	-	.5	[illegible]	[illegible]	1.5	19.9	12,[illegible]	-	-	-	-
"	"	Dietz No. [illegible]		No. [illegible]	22.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50.6	[illegible]	[illegible]	9,[illegible]	11,871	-	-	-
"	"	"		"	-	[illegible]	47.5	10.[illegible]	1.4	[illegible]	[illegible]	[illegible]	18.6	11,[illegible]	-	-	-	-
"	"	"		"	-	47.[illegible]	53.0	-	[illegible]	[illegible]	76.3	[illegible]	[illegible]	12,[illegible]	-	-	-	-
"	"	"		"	22.5	[illegible]	[illegible]	[illegible]	[illegible]	6.1	[illegible]	[illegible]	[illegible]	9,[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	48.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,[illegible]	-	-	-	-
"	"	"		"	-	47.[illegible]	53.0	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,[illegible]	-	-	-	-
"	"	Dietz No. [illegible]		No. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	6.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,[illegible]	-	-	-	-
"	"	Dietz No. [illegible]		No. 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,[illegible]	-	-	-	-
"	"	"		"	-	41.[illegible]	50.8	8.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,[illegible]	-	-	-	-
"	"	"		"	-	44.[illegible]	55.3	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,[illegible]	-	-	-	-
"	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7,[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Proximate analysis, % Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Sheridan	Kendrick Kool	Sweat's Kool		Arvada	-	46.0	54.0	-	1.5	4.9	71.6	1.4	20.7	12,220	-	-	-	-
*				Monarch	23.5	31.2	40.4	4.9	.5	6.6	52.0	1.0	35.0	9,120	-	-	-	-
*	*	*		*	-	40.8	52.8	6.4	.7	5.2	68.0	1.1	18.6	11,920	-	-	-	-
*	*	*		*	-	43.6	56.4	-	.7	5.6	72.6	1.3	19.9	12,740	-	-	-	-
*	*	*		*	23.4	33.9	38.0	4.7	.6	6.1	53.1	1.3	34.0	9,215	-	-	-	-
*	*	*		*	-	44.2	49.7	6.1	.8	4.8	69.1	1.6	17.6	12,010	-	-	-	-
*	*	*		*	-	47.1	52.9	-	.9	5.2	73.8	1.7	18.4	12,800	-	-	-	-
*	*	*		*	23.7	32.6	38.8	4.9	.7	6.5	53.9	1.1	37.9	9,150	-	-	-	-
*	*	*		*	-	42.7	50.9	6.4	.9	5.0	70.7	1.4	15.6	12,020	-	-	-	-
*	*	*		*	-	45.6	54.4	-	.9	5.1	75.5	1.5	16.9	12,740	-	-	-	-
*	Monarch	Monarch		*	22.3	35.0	39.0	3.7	.6	6.1	55.1	1.1	33.2	9,620	-	2,130	-	-
*	*	*		*	-	45.2	50.0	4.8	.5	4.9	71.1	1.4	17.1	12,370	-	-	-	-
*	*	*		*	-	47.3	52.7	-	.5	5.1	74.7	1.5	18.2	12,990	-	-	-	-
*	*	*		*	23.1	31.9	41.8	3.2	.4	6.6	56.7	1.1	34.7	9,480	-	2,200	-	-
*	*	*		*	-	41.4	54.4	4.2	.5	5.0	71.0	1.4	17.9	12,330	-	-	-	-
*	*	*		*	-	43.3	56.7	-	.5	5.3	74.1	1.5	18.6	12,870	-	-	-	-
*	*	*		*	23.4	33.6	39.4	3.6	.4	6.4	56.4	1.0	34.2	9,490	-	2,270	-	-
*	*	*		*	-	43.8	51.5	4.7	.5	5.0	71.0	1.3	17.5	12,360	-	-	-	-
*	*	*		*	-	46.0	54.0	-	.5	5.2	74.5	1.4	18.4	12,815	-	-	-	-
*	*	*		*	23.3	33.9	38.9	3.9	.5	6.5	54.8	1.2	33.1	9,490	-	-	-	-
*	*	*		*	-	44.2	50.7	5.1	.7	5.0	71.5	1.5	16.2	12,380	-	-	-	-
*	*	*		*	-	46.5	53.5	-	.7	5.3	75.3	1.6	17.1	13,040	-	-	-	-
*	*	*		*	23.1	34.6	38.7	3.6	.4	6.5	55.1	1.1	33.3	9,550	-	1,980	-	-
*	*	*		*	-	45.0	50.3	4.7	.6	5.1	71.7	1.5	16.4	12,430	-	-	-	-
*	*	*		*	-	47.2	52.8	-	.6	5.3	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
*	*	*		*	23.2	[illegible]	[illegible]	[illegible]	.4	6.4	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
				*	-	[illegible]	[illegible]	[illegible]	.6	5.0	71.1	1.3	17.1	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

Wyoming (continued)

[illegible]

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu, as received	Sp gr	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Wyoming (continued)													
Sweetwater	Overland	Hutchinson No. 2		Monarch	-	45.2	54.8	-	.5	6.0	73.4	1.3	18.7	13,080	-	-	-	-
Sweet-water	Black Buttes	Rock Springs		Unnamed	18.9	29.2	47.8	4.1	.5	5.8	59.0	1.5	29.1	10,280	-	-	-	-
"	"	Gibraltar		"	-	36.0	58.9	5.1	.6	4.9	72.7	1.6	15.4	12,570	-	-	-	-
"	"	"		"	-	37.9	62.1	-	.6	5.6	76.5	1.9	16.4	13,350	-	-	-	-
"	"	"		"	20.9	28.3	47.1	3.7	.4	6.0	57.1	1.1	31.7	9,910	-	-	-	-
"	"	"		"	-	35.8	59.5	4.7	.5	4.6	72.1	1.3	16.8	12,510	-	-	-	-
"	"	"		"	-	37.6	62.4	-	.5	4.9	75.6	1.4	17.6	13,130	-	-	-	-
"	"	"		"	18.9	28.9	48.1	4.1	.4	5.9	59.2	1.4	29.1	10,090	-	-	-	-
"	"	"		"	-	35.7	59.2	5.1	.5	4.6	73.3	1.6	15.0	12,440	-	-	-	-
"	"	"		"	-	37.6	62.4	-	.6	4.8	76.9	1.9	15.8	13,110	-	-	-	-
"	"	"		"	17.2	30.3	48.3	4.2	.4	5.5	58.2	1.5	33.3	9,990	-	-	-	-
"	"	"		"	-	36.6	58.3	5.1	.4	4.2	67.9	1.8	20.6	11,360	-	-	-	-
"	"	"		"	-	38.6	61.4	-	.4	4.4	71.6	1.9	21.7	11,950	-	-	-	-
"	"	"		"	18.7	29.2	48.4	3.7	.4	5.8	58.5	1.4	30.2	10,050	-	-	-	-
"	"	"		"	-	36.0	59.4	4.6	.5	4.6	71.5	1.6	16.7	12,360	-	-	-	-
"	"	"		"	-	37.7	62.3	-	.6	4.8	75.1	1.9	17.5	12,950	-	-	-	-
"	"	"		"	19.5	28.2	47.8	4.5	.4	5.9	57.1	1.4	30.6	9,840	-	-	-	-
"	"	"		"	-	35.1	59.4	5.5	.5	4.6	71.3	1.7	16.4	12,230	-	-	-	-
"	"	"		"	-	37.1	62.9	-	.5	4.9	75.4	1.8	17.4	12,930	-	-	-	-
"	"	Rock Springs Sioux City		"	16.7	29.3	49.5	4.5	.3	5.5	59.7	1.1	28.8	10,150	-	-	-	-
"	"	"		"	-	35.2	59.4	5.4	.3	4.3	71.6	1.3	16.5	12,190	-	-	-	-
"	"	"		"	-	37.2	62.8	-	.4	4.6	75.8	1.4	17.6	13,120	-	-	-	-
"	Sup[illegible]	[illegible] 3		Upper Yaeger	11.3	33.7	47.3	7.7	1.1	5.7	61.8	1.3	26.1	[illegible]	-	-	-	-

Table D-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, %: Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Wyoming (continued)													
Sweet Water	Point of Rocks	Point of Rocks		Lower	16.6	30.2	44.0	9.2	.7	5.8	55.6	1.1	28.1	9,410	-	-	-	-
"	"	"		"	-	36.1	52.7	11.0	.8	4.1	66.7	1.3	16.1	11,280	-	-	-	-
"	"	"		"	-	40.8	59.2	-	.9	4.6	75.0	1.5	18.0	12,690	-	-	-	-
"	"	"		Upper	16.1	33.2	46.4	4.3	.8	5.0	[illegible]	1.2	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	39.5	55.4	5.1	.9	4.9	70.7	1.4	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	41.7	58.3	-	1.0	5.1	74.6	1.5	17.8	[illegible]	-	-	-	-
"	"	"		"	14.1	33.2	47.1	5.4	.7	4.7	59.0	1.4	33.6	8,190	-	-	-	-
"	"	"		"	-	38.8	54.6	6.6	.9	3.8	61.7	1.6	26.4	9,730	-	-	-	-
"	"	"		"	-	41.5	58.5	-	.9	3.9	67.5	1.7	26.0	10,880	-	-	-	-
"	"	"		"	14.0	31.1	50.8	4.1	.6	5.4	60.3	1.3	28.3	[illegible]	-	-	-	-
"	"	"		"	-	36.2	59.0	4.8	.7	4.5	70.1	1.5	18.4	[illegible]	-	-	-	-
"	"	"		"	-	38.0	62.0	-	.7	4.7	73.6	1.5	[illegible]	[illegible]	-	-	-	-
"	"	"		"	16.9	27.8	51.8	3.5	.6	5.8	60.6	1.2	28.4	[illegible]	-	-	-	-
"	"	"		"	-	34.1	61.8	4.1	.7	4.7	73.0	1.5	16.0	12,590	-	-	-	-
"	"	"		"	-	35.6	64.4	-	.7	4.9	76.1	1.6	16.7	[illegible]	-	-	-	-
"	"	"		"	17.9	29.5	49.3	3.3	.5	5.9	59.5	1.2	29.6	[illegible]	-	-	-	-
"	"	"		"	-	36.0	60.0	4.0	.6	4.7	72.4	1.5	16.8	12,450	-	-	-	-
"	"	"		"	-	37.5	62.5	-	.6	4.9	75.4	1.6	17.5	12,970	-	-	-	-
"	"	"		"	18.8	29.5	48.2	3.5	.6	5.9	[illegible]	1.2	29.3	[illegible]	-	-	-	-
"	"	"		"	-	36.3	59.4	4.3	.7	4.7	[illegible]	1.5	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	37.9	62.1	-	.7	4.9	76.0	1.6	15.8	[illegible]	-	-	-	-
"	Rock Springs	Union Pacific No. 4		No. 1	9.3	35.6	49.6	5.5	.8	5.4	66.2	1.2	20.9	[illegible]	-	-	-	-
"	"	"		"	-	37.9	[illegible]	[illegible]	.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	41.5	58.5	-	.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
		Rock Springs No. 4		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Proximate analysis, % Volatile matter	Proximate analysis, % Fixed carbon	Ultimate analysis, % Ash	Ultimate analysis, % Sulfur	Ultimate analysis, % Hydrogen	Ultimate analysis, % Carbon	Ultimate analysis, % Nitrogen	Ultimate analysis, % Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
							Wyoming (continued)											
Sweet-water	Rock Springs	Rock Springs No. 4		No. 1	-	40.4	53.4	5.7	.X	4.9	[illegible]	1.4	13.8	12,2[illegible]	-	-	-	-
"	"	"		"	-	41.8	58.2	-	.8	5.3	77.4	1.7	14.9	13,260	-	-	-	-
"	"	Sweetwater No.2		No. 7	4.8	37.3	48.6	9.3	.8	5.5	61.8	1.1	19.7	10,9[illegible]	-	-	-	-
"	"	"		"	-	36.1	51.8	10.0	1.0	4.9	70.7	1.2	12.3	12,530	-	-	-	-
"	"	"		"	-	40.2	59.8	-	1.1	5.5	78.5	1.3	13.5	13,905	-	-	-	-
"	"	Union Pacific Old No. 1		No. 5	10.9	33.8	40.7	15.6	1.0	4.8	56.5	.8	21.7	9,900	-	-	-	-
"	"	"		"	-	36.2	47.9	17.5	1.1	4.1	63.6	1.0	15.7	10,840	-	-	-	-
"	"	"		"	-	41.9	58.1	-	1.4	5.0	75.8	1.2	19.1	13,[illegible]	-	-	-	-
"	"	Blairtown		No. 3	11.5	35.7	52.1	1.8	.8	5.9	68.9	1.2	22.2	11,[illegible]	-	-	-	-
"	"	"		"	-	41.6	55.6	1.3	.9	5.8	77.2	1.3	13.5	13,805	-	-	-	-
"	"	"		"	-	42.4	57.6	-	.9	5.8	78.6	1.1	13.8	14,075	-	-	-	-
"	"	Union Pacific No. 1		No. 7	14.5	33.1	47.1	5.2	1.0	5.6	61.5	1.1	25.5	10,980	-	-	-	-
"	"	"		"	-	37.2	55.7	6.1	1.1	5.0	[illegible]	1.3	15.5	12,[illegible]	-	-	-	-
"	"	"		"	-	41.4	58.6	-	1.1	5.3	75.7	1.4	16.2	13,[illegible]	-	-	-	-
"	"	Union Pacific No. 20		"	13.2	34.8	47.7	5.2	.8	5.9	64.9	1.2	26.0	11,[illegible]	-	-	-	-
"	"	"		"	-	39.1	55.2	5.7	.9	5.3	74.6	1.4	19.1	13,250	-	-	-	-
"	"	"		"	-	40.6	59.4	-	.9	5.6	79.7	1.4	14.9	13,750	-	-	-	-
"	"	Old No. 8		No. 9	13.1	30.5	51.9	4.4	.8	5.9	61.1	1.4	27.2	11,[illegible]	-	-	-	-
"	"	"		"	-	35.2	59.8	5.1	.5	4.9	75.2	1.6	17.7	12,150	-	-	-	-
"	"	"		"	-	37.2	62.9	-	.5	5.3	79.4	1.6	18.6	12,800	-	-	-	-
"	"	[illegible]		No. 7	[illegible]	36.4	50.0	[illegible]	.5	5.4	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
Wyoming (continued)																		
Sweet-water	Rock Springs	No. 5		No. 7	-	41.7	58.3	-	1.0	4.8	79.0	1.0	13.7	14,000	-	-	-	-
"	"	No. 4		"	9.8	34.3	52.5	3.4	1.0	5.8	68.4	1.2	20.2	12,260	-	-	-	-
"	"	"		"	-	38.0	58.2	3.8	1.1	5.2	75.8	1.4	12.7	13,700	-	-	-	-
"	"	"		"	-	39.5	60.5	-	1.2	5.4	78.9	1.4	13.2	14,050	-	-	-	-
"	"	Prospect		Unnamed	19.8	35.7	37.8	6.7	.7	5.1	48.1	1.3	38.1	12,760	-	-	-	-
"	"	"		"	-	44.5	47.1	8.4	.8	3.6	60.1	1.7	25.4	13,580	-	-	-	-
"	"	"		"	-	48.6	51.4	-	.9	4.0	65.5	1.8	27.8	14,120	-	-	-	-
"	"	"		"	21.0	31.3	40.1	7.6	.8	5.4	49.6	1.0	35.6	8,700	-	-	-	-
"	"	"		"	-	39.7	50.7	9.6	1.0	3.8	62.7	1.3	21.6	10,330	-	-	-	-
"	"	"		"	-	43.9	56.1	-	1.1	4.3	69.4	1.5	23.7	11,490	-	-	-	-
"	"	Interstate		Inter-state	13.4	36.3	41.8	8.5	.8	5.9	59.8	1.2	23.8	10,460	-	-	-	-
"	"	"		"	-	41.9	48.3	9.8	1.0	5.1	69.1	1.3	13.7	12,080	-	-	-	-
	"	"		"	-	46.4	53.6	-	1.1	5.6	76.6	1.5	15.2	13,390	-	-	-	-
"	"	Kappes		Unnamed	24.2	32.1	40.0	3.7	.5	5.6	49.2	1.1	30.9	7,840	-	-	-	-
"	"	"		"	-	42.4	52.7	4.9	.6	3.8	64.9	1.4	24.4	10,410	-	-	-	-
"	"	"		"	-	44.6	55.4	-	.7	4.0	68.2	1.5	25.6	10,950	-	-	-	-
"	"	Kent		"	13.1	35.6	45.6	5.7	.4	5.9	62.9	1.2	22.0	11,110	-	-	-	-
"	"	"		"	-	40.9	52.5	6.6	1.6	5.2	72.1	1.4	12.9	12,790	-	-	-	-
"	"	"		"	-	43.8	56.2	-	1.7	5.5	77.4	1.5	13.9	13,690	-	-	-	-
"	"	Miller		"	12.8	34.8	49.9	2.5	.8	5.8	64.8	1.3	24.8	11,360	-	-	-	-
"	"	"		"	-	39.9	57.2	2.9	.9	6.1	74.3	1.5	15.1	13,030	-	-	-	-
"	"	"		"	-	41.1	58.9	-	.9	5.2	76.6	1.5	15.9	13,410	-	-	-	-
"	"	[illegible]		"	[illegible]	35.3	43.5	15.6	1.0	5.6	61.7	1.3	19.8	11,180	-	-	-	-
"	"	"		"	-	[illegible]	46.2	[illegible]	[illegible]	[illegible]	67.3	1.5	13.6	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate analysis, % Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Sweet-water	Rock Springs	McKinney		Unnamed	-	47.7	52.3	-	1.2	5.7	75.9	1.6	15.6	11,690	-	-	-	-
"	"	Myers		"	11.8	38.9	42.2	5.1	5.5	6.1	60.1	1.7	21.3	11,110	-	2,050	-	-
"	"	"		"	-	45.1	49.0	5.9	6.4	5.3	69.9	2.0	10.5	12,920	-	-	-	-
"	"	"		"	-	48.0	52.0	-	6.8	5.6	74.3	2.1	11.2	13,780	-	-	-	-
"	Superior	Superior C		No. 1	13.7	32.4	51.0	2.9	.7	5.8	67.0	1.2	23.5	11,460	-	-	-	-
"	"	"		"	-	37.6	58.6	3.6	.8	5.0	76.4	1.4	13.0	13,190	-	-	-	-
"	"	"		"	-	38.9	61.1	-	.9	5.2	79.0	1.4	13.5	13,860	-	-	-	-
"	"	"		"	13.1	35.8	47.7	3.4	1.0	5.9	68.2	1.3	22.2	11,620	-	-	-	-
"	"	"		"	-	41.1	55.0	3.9	1.2	5.1	76.2	1.4	12.2	12,370	-	-	-	-
"	"	"		"	-	42.8	57.2	-	1.2	5.3	79.3	1.5	12.7	13,900	-	-	-	-
"	"	Superior D		"	11.8	34.3	50.5	4.2	1.1	5.7	63.5	1.1	23.9	11,430	-	-	-	-
"	"	"		"	-	36.6	58.5	4.9	1.5	4.8	74.0	1.3	13.5	13,250	-	-	-	-
"	"	"		"	-	38.6	61.4	-	1.6	5.1	77.8	1.3	14.2	13,930	-	-	-	-
"	"	"		"	14.5	34.1	47.9	3.5	1.0	5.8	63.5	1.3	24.9	11,370	-	-	-	-
"	"	"		"	-	40.3	55.8	4.2	1.2	4.9	74.8	1.6	13.3	13,130	-	-	-	-
"	"	"		"	-	41.7	58.3	-	1.2	5.1	77.5	1.6	14.6	13,910	-	-	-	-
"	"	Prospect		No. 3	18.4	31.6	48.4	1.6	.5	6.5	57.4	1.2	33.7	9,670	-	-	-	-
"	"	"		"	-	40.2	57.8	2.0	.6	4.2	70.3	1.6	21.4	11,850	-	-	-	-
"	"	"		"	-	41.1	58.9	-	.6	4.3	71.7	1.5	21.9	12,090	-	-	-	-
"	"	Superior A		No. 7	12.7	32.8	50.0	4.5	.8	5.8	65.1	1.1	22.7	11,720	-	-	-	-
"	"	"		"	-	37.6	57.2	5.2	.9	5.0	75.6	1.3	14.0	13,430	-	-	-	-
"	"	"		"	-	39.7	60.3	-	.9	5.3	79.7	1.4	13.7	14,160	-	-	-	-
"	"	"		No. 1	10.6	34.8	50.4	4.2	.9	5.7	67.1	1.1	20.9	12,150	-	-	-	-
"	"	"		"	-	38.9	56.4	4.7	1.0	5.0	75.1	1.4	17.8	13,600	-	-	-	-
"	"	"		"	-	40.3	59.7	-	1.0	5.3	79.0	1.5	13.4	14,190	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Type of mine	Bed	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Ash	Ultimate analysis, %: Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									Wyoming (continued)									
Uinta	Almy	[illegible]		Almy	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	2,290	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	Spring Valley	[illegible]		Spring Valley	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.7	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.9	[illegible]	10,580	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
[illegible]	[illegible]	Antelope No. 1		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.7	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.8	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	Antelope No. 4		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.8	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	[illegible]	[illegible]		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	[illegible]		"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.8	[illegible]	[illegible]	-	[illegible]	-	-
"	"	"		"	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
"	"	"		"	-	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Proximate analysis, %: Ash	Ultimate analysis, %: Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Sheridan	Sheridan	Big Horn		Monarch	22.9	41.4	51.2	7.4	.9	-	-	-	-	9,300	12,130	2,120	-	-
"	"	"		"	21.9	41.9	51.5	6.6	.7	-	-	-	-	9,570	12,250	2,100	-	-
Lincoln	Kemmerer	Elkol		"	21.2	42.3	54.2	3.5	.9	-	-	-	-	10,010	12,720	-	-	-
Sheridan	Sheridan	Big Horn		"	21.7	41.7	52.3	6.0	.5	-	-	-	-	9,590	12,250	2,110	-	-
"	"	"		"	23.0	42.6	51.7	5.7	.8	-	-	-	-	9,500	12,360	2,170	-	-
"	"	"		"	21.4	41.7	49.9	8.4	.8	-	-	-	-	9,540	12,200	2,070	-	-
"	"	"		"	21.8	42.3	51.5	6.2	.6	-	-	-	-	9,540	12,290	2,070	-	-
Sweetwater	Reliance	Reliance Auger		Rock Spring No. 1	16.3	46.4	49.2	4.4	1.0	5.1	72.9	1.6	15.0	10,700	12,790	2,190	-	-
"	"	Reliance Strip		Rock Spring No. 11	15.5	45.0	47.1	7.9	1.0	5.0	71.4	1.6	13.1	10,600	12,550	2,040	-	-
Lincoln	Adaville	Elkol			19.4	34.5	62.0	3.5	.9	6.1	58.2	1.1	30.0	10,570	-	-	-	-
"	Lower Willow Creek	Coredrill			7.5	41.1	50.6	5.8	1.6	5.6	74.4	1.3	11.5	14,350	-	-	-	-
"	Spring Valley	Lenz			4.1	39.7	48.2	12.1	.6	4.7	68.6	1.2	14.1	13,940	-	-	-	-
"	Willow Creek	Coredrill			3.7	37.3	53.6	9.1	.7	5.2	71.8	1.1	12.1	14,120	-	-	-	-
"	"	"			3.4	38.1	[illegible]	10.8	1.1	5.2	69.5	1.1	12.3	14,180	-	-	-	-
"	"	"			3.1	[illegible]	53.1	7.9	1.1	5.5	72.8	1.7	11.9	14,170	-	-	-	-
"	"	"			[illegible]	37.4	[illegible]	9.1	.7	5.4	72.7	1.2	11.8	14,250	-	-	-	-
"	"	[illegible]			2.9	39.2	[illegible]	9.4	1.2	5.5	[illegible]	1.3	11.9	14,370	-	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine Name	Mine Date of analysis	Seam	Proximate analysis, % Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, % Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening tempera- ture, °F	Free swelling index	Hardgrove grindability index
									Wyoming (continued)									
[illegible]	[illegible]	[illegible]			[illegible]	45.1	[illegible]	[illegible]	.3	-	-	-	-	11,940	[illegible]	2,[illegible]	-	-
"	"	"			11.2	44.0	50.1	5.9	.3	-	-	-	-	11,590	12,490	2,270	-	-
"	"	"			12.1	43.7	50.2	6.1	.5	-	-	-	-	11,030	12,550	2,365	-	-
Hot Springs	Grass Creek	Grass Creek			13.4	45.3	46.7	8.0*	.4	-	-	-	-	10,060	[illegible]	[illegible]	-	-
"	"	"			12.3	42.4	48.0	9.6	.6	-	-	-	-	10,790	12,300	2,620	-	-
"	"	"			13.5	42.1	48.6	9.3	.4	-	-	-	-	10,[illegible]	12,[illegible]	2,[illegible]	-	-
"	"	"			12.9	40.2	48.7	11.1	.4	-	-	-	-	10,[illegible]	12,150	2,51[illegible]	-	52
"	"	"			12.7	41.4	49.1	9.5	.5	-	-	-	-	10,[illegible]	12,[illegible]	2,[illegible]	-	-
Lincoln	Kemmerer	Elkol			21.6	42.1	53.3	4.6	.8	-	-	-	-	9,960	12,[illegible]	2,400	-	-
"	"	"			20.7	42.8	53.[illegible]	4.0	.8	-	-	-	-	10,170	12,820	2,405	-	-
"	"	"			19.7	42.5	54.[illegible]	3.0	.7	-	-	-	-	10,370	12,[illegible]	-	-	-
"	"	"			22.4	31.9	52.[illegible]	5.4	.8	-	-	-	-	9,770	12,590	2,418	-	-
Sheridan	Sheridan	Big Horn		Monarch	24.1	41.3	53.1	5.[illegible]	.4	-	-	-	-	9,200	12,150	2,180	-	-
"	"	"		"	24.1	41.6	53.0	5.4	.4	-	-	-	-	9,235	12,140	2,270	-	-
"	"	"		"	24.2	41.8	52.4	5.8	.5	-	-	-	-	9,150	12,11[illegible]	2,180	-	-
"	"	"		"	21.0	43.6	50.7	5.9	.5	-	-	-	-	9,960	12,490	2,080	-	43
"	"	"		"	25.5	[illegible]	51.[illegible]	4.9	.5	-	-	-	-	9,740	12,[illegible]	2,100	-	-
"	"	"		"	23.5	42.7	51.9	5.6	.5	-	-	-	-	9,[illegible]	12,[illegible]	2,[illegible]	-	-
"	"	"		"	19.9	40.7	53.3	6.0	.7	-	-	-	-	9,260	12,090	2,130	-	-
"	"	"		"	22.3	42.1	51.9	5.[illegible]	.5	-	-	-	-	9,580	12,130	2,105	-	-
					[illegible]	40.[illegible]	52.7	5.1	.5	-	-	-	-	9,[illegible]	12,[illegible]	2,190	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Ultimate analysis, %: Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu Dry	Ash softening temperature °F	Free swelling index	Hardgrove grindability index
					Wyoming (continued)													
Sweetwater	Rock Springs	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	.9	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*			[illegible]	[illegible]	[illegible]	[illegible]	.8	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*			[illegible]	[illegible]	[illegible]	[illegible]	.8	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*			[illegible]	[illegible]	[illegible]	[illegible]	.9	*	*	*	*	[illegible]	[illegible]	[illegible]	*	52
*	*	*			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*
Campbell	Gillette	Wyodak		Smith-Roland	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	[illegible]
*	*	*		*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	[illegible]
Carbon	Hanna	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
Lincoln	Kemmerer	Elkol		Adaville	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
Sheridan	Acme	Big Horn		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*		*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	[illegible]
*	*	*		*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*		*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*		*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	[illegible]

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %								
County	Coal field or town	Name	Date of analysis	Seam	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
					Wyoming (continued)													
Carbon	Hanna	Hanna			15.8	38.7	37.7	8.6	1.0	*	*	*	*	10,[illegible]	11,470	2,100	*	*
Lincoln *	* *	Elkol Sorensen		Adaville	20.2 20.6	42.7 43.9	56.5 50.8	2.8 5.3	.2 .3	* *	* *	* *	* *	10,310 9,825	12,925 11,730	* 2,730	* *	* 64
Sheridan *	Sheridan *	Big Horn *		Monarch *	21.6 22.6	33.1 42.4	51.3 52.2	5.4 5.4	.6 .5	* *	* *	* *	* *	9,[illegible] 9,500	12,060 12,390	2,170 2,210	* *	* *
Sweetwater *	Rock Springs *	[illegible]			5.8	42.2	51.3	1.8	.8	5.4	74.7	1.8	12.8	12,440	11,912	2,750	*	*
		*			10.2	42.5	55.2	2.0	.7	*	*	*	*	12,420	13,[illegible]	2,750	*	*
Lincoln	Kemmerer	Elkol		Adaville	20.4	34.1	43.6	3.1	.7	*	*	*	*	10,250	12,[illegible]	*	*	*
Sheridan *	Sheridan *	Big Horn *		Monarch *	22.1 21.3	34.7 42.8	48.6 51.6	5.7 5.6	.7 .5	* *	* *	* *	* *	11,[illegible] 9,630	12,640 12,[illegible]	2,190 2,[illegible]	* *	* *
Lincoln	Kemmerer	Elkol		Adaville	20.0	41.0	58.3	3.3	.7	*	*	*	*	10,2[illegible]	12,81[illegible]	*	*	*
Sheridan *	Sheridan *	Big Horn *		Monarch *	21.7 20.2	44.8 43.7	40.1 51.8	3.7 5.2	.8 .5	* *	* *	* *	* *	9,950 9,590	12,580 12,380	2,160 2,220	* *	* *
Carbon	Hanna	Hanna		[illegible]	11.3	42.7	50.6	7.8	.8	*	*	*	*	10,900	12,250	2,160	*	*
Lincoln	Kemmerer	Elkol		Adaville	[illegible]	[illegible]	[illegible]	3.1	.8	*	*	*	*	10,2[illegible]	12,[illegible]	*	*	*

Table 3-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

[illegible]

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %				Ultimate analysis, %									
County	Coal field or town	Name	Date of analysis	Bed	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
						Wyoming (continued)												
Carbon	Hanna	Hanna 4	[illegible]		12.4	41.1	47.5	5.7	.8	-	-	-	-	10,790	12,210	-	-	-
"	"	"	[illegible]		11.9	44.4	48.2	7.4	.5	-	-	-	-	10,890	12,360	2,210	-	-
"	"	"	[illegible]		12.1	44.4	47.4	8.2	.5	-	-	-	-	10,820	12,300	2,260	-	-
"	"	"	[illegible]		10.7	45.5	47.5	7.0	.5	-	-	-	-	11,190	12,465	2,170	-	-
"	"	"	[illegible]		11.2	41.7	49.3	7.8	.5	-	-	-	-	10,660	12,170	-	-	-
"	"	"	[illegible]		13.8	44.1	48.9	6.8	.5	-	-	-	-	10,840	12,560	2,220	-	-
"	"	Shirley Basin	[illegible]		17.4	43.2	46.8	11.1	.8	-	-	-	-	10,130	12,210	2,950	-	-
"	"	"	[illegible]		17.1	42.1	47.1	11.5	.6	-	-	-	-	10,490	11,710	2,950	-	-
Hot Springs	Gebo	[illegible] Mines	1948	Nos. 3 & 5	15.9	38.9	54.6	6.5	.7	-	-	-	-	13,750	12,790	2,490	-	-
"	"	"	1948	"	16.1	39.7	54.1	6.2	.6	5.0	73.4	1.1	11.5	12,830	12,917	2,520	-	-
"	"	"	1948	"	14.0	39.1	51.3	6.9	.6	-	-	-	-	10,910	12,710	2,540	-	-
"	"	"	1948	"	13.9	41.2	55.8	8.0	.7	-	-	-	-	11,210	12,680	-	-	-
"	"	"	1948	"	15.1	37.3	50.5	12.2	.7	-	-	-	-	10,130	11,950	2,380	-	-
"	"	"	1948	"	14.7	37.3	51.7	11.0	.7	-	-	-	-	10,160	12,140	2,420	-	-
Lincoln	Brilliant	Brilliant No. 2	1948	Frontier No. 1	4.0	44.5	47.7	7.8	.6	-	-	-	-	12,490	12,800	-	-	-
"	"	"	1947	"	4.7	53.9	46.5	9.2	.8	-	-	-	-	12,110	12,760	-	-	-
"	"	"	1948	"	8.2	47.4	48.1	9.4	.5	-	-	-	-	11,710	12,760	2,130	-	-
"	"	"	1948	"	9.2	41.9	48.5	10.3	.3	-	-	-	-	11,480	12,710	2,180	-	-
"	Elkol	Elkol	[illegible]	Adaville	[illegible]	44.4	51.8	4.4	.6	-	-	-	-	11,220	12,740	-	-	-
Sheridan	Sheridan	Big Horn No. 1	1948	Carney	[illegible]	33.3	44.1	7.1	[illegible]	-	-	-	-	9,140	11,813	-	-	-

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

Table G-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

County	Coal field or town	Mine: Name	Mine: Date of analysis	Seam	Proximate analysis, %: Moisture	Proximate analysis, %: Volatile matter	Proximate analysis, %: Fixed carbon	Ash	Sulfur	Ultimate analysis, %: Hydrogen	Ultimate analysis, %: Carbon	Ultimate analysis, %: Nitrogen	Ultimate analysis, %: Oxygen	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
									Wyoming (continued)									
Sweetwater	Dines	Dines	[illegible]	No. [illegible]	12.[illegible]	41.[illegible]	55.8	3.0	.7	-	-	-	-	11,[illegible]	13,[illegible]	-	-	-
"	"	"	1950	"	14.5	41.7	54.8	3.[illegible]	.7	-	-	-	-	11,220	13,1[illegible]	-	-	-
"	"	"	1950	"	14.3	41.5	54.6	3.9	.7	-	-	-	-	11,200	13,[illegible]	2,[illegible]90	-	-
"	"	"	1948	"	14.6	41.6	55.1	3.3	.9	-	-	-	-	11,180	13,090	-	-	-
"	"	"	1950	"	13.3	41.7	55.1	3.[illegible]	.6	-	-	-	-	11,[illegible]	13,[illegible]	-	-	-
"	"	"	1949	"	14.1	42.0	54.[illegible]	3.8	.7	-	-	-	-	11,330	13,190	-	-	-
"	"	"	1948	"	14.3	42.[illegible]	54.1	3.9	.8	-	-	-	-	11,300	13,190	-	-	-
"	"	"	[illegible]	"	13.6	41.[illegible]	55.4	3.4	.6	-	-	-	-	11,[illegible]	13,[illegible]	-	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	11,[illegible]	13,[illegible]	-	-	-
"	"	"	1950	"	13.9	41.4	[illegible]	4.[illegible]	.8	-	-	-	-	11,[illegible]	13,[illegible]	2,[illegible]	-	-
"	"	"	1950	"	13.7	41.7	[illegible]	3.5	.8	-	-	-	-	11,[illegible]	13,[illegible]	2,[illegible]	-	-
"	"	"	1948	"	15.1	41.4	54.[illegible]	3.6	.7	-	-	-	-	11,300	13,[illegible]	-	-	-
"	"	"	1949	"	14.8	42.[illegible]	53.4	4.4	.8	-	-	-	-	11,160	13,[illegible]	2,[illegible]	-	-
"	"	"	1945	"	16.3	41.3	54.8	4.2	.9	5.4	[illegible]	1.5	[illegible]	11,[illegible]	13,[illegible]	[illegible]	-	-
"	"	"	1948	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	10,[illegible]	13,[illegible]	[illegible]	-	-
"	"	"	1949	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1950	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1948	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	[illegible]	[illegible]	-	-	-
"	"	"	1949	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	10,[illegible]	12,[illegible]	[illegible]	-	-
"	"	"	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	10,[illegible]	12,[illegible]	[illegible]	-	-
"	"	"	1948	"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	10,[illegible]	[illegible]	[illegible]	-	-
Sweetwater	Quealy	Sweetwater No. [illegible]	[illegible]	[illegible] Springs	[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]	-	-	-	-	1[illegible],[illegible]	13,[illegible]	-	-	-
"	"	"	1948	"	[illegible]	[illegible]	[illegible]	4.8	.8	-	-	-	-	1[illegible],[illegible]	1[illegible],[illegible]	[illegible]	-	-

Table U-1 (continued). WESTERN COAL COMPOSITION & PHYSICAL PROPERTIES

		Mine			Proximate analysis, %					Ultimate analysis, %							
County	Coal field or town	[illegible]	Date of analysis (yr)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Btu as received	Btu dry	Ash softening temperature, °F	Free swelling index	Hardgrove grindability index
								Wyoming (continued)										
Sweetwater	[illegible]	Sweetwater	[illegible]	Rock Springs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	Superior	Klondyke	[illegible]	No. 1 & 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.4	77.5	1.7	13.8	[illegible]	[illegible]	[illegible]	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	[illegible]	*	*
*	Rock Springs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*
*	*	*	[illegible]	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	[illegible]	[illegible]	*	*	*

APPENDIX H

PERTINENT CONVERSION FACTORS

BRITISH TO INTERNATIONAL SYSTEM OF UNITS (SI)

Table H-1. CONVERSION FACTORS, BRITISH TO SI

To convert from	To	Multiply by
acre	metre² (m²)	4.047 × 10³
British thermal unit (Btu)	joule (J)	1.055 × 10³
British thermal unit/pound-mass (Btu/lb)	joule/kilogram (J/kg)	2.326 × 10³
Btu/foot²-hour	watt/metre² (W/m²)	3.152 × 10⁰
Btu/hour-foot²	watt/metre² (W/m²)	[illegible]
cents/short ton	cents/kilogram (¢/kg)	1.102 × 10⁻³
cents/short ton-mile	cents/kilogram-metre (¢/kg·m)	6.851 × 10⁻⁷
degree Celsius (°C)	kelvin (K)	$t_K = t_C + 273.15$
degree Fahrenheit (°F)	degree Celsius	$t_C = (t_F - 32)/1.8$
degree Fahrenheit (°F)	kelvin (K)	$t_K = (t_F + 459.67)/1.8$
dollars/10⁶ Btu	dollars/10⁹ joules ($/10⁹J)	9.479 × 10⁻¹
foot (ft)	metre (m)	3.048 × 10⁻¹
foot³ (cu ft)	metre³ (m³)	2.832 × 10⁻²
foot² (sq ft)	metre² (m²)	9.290 × 10⁻²
gallon (gal)	metre³ (m³)	3.785 × 10⁻³
10⁶ gallons/day (mgd)	metre³/second (m³/s)	4.381 × 10⁻²
gram (gm)	kilogram (kg)	1.000 × 10⁻³
hour (h)	second (s)	3.600 × 10³
inch (in)	metre (m)	2.540 × 10⁻²
inch² (sq in)	metre² (m²)	6.452 × 10⁻⁴
inch³ (cu in)	metre³ (m³)	1.639 × 10⁻⁵
kilowatt-hour (kWh)	joule (J)	3.600 × 10⁶
mile (mi)	metre (m)	1.609 × 10³
mile² (mi²)	metre² (m²)	2.590 × 10⁶
minute (min)	second (s)	6.000 × 10¹
pound-mass/hour	kilogram/second (kg/s)	[illegible]
pound-mass (lbm)	kilogram (kg)	4.536 × 10⁻¹
ton (long)	kilogram (kg)	1.016 × 10³
ton (short)	kilogram (kg)	9.072 × 10²
watt-hour	joule (J)	3.600 × 10³
yard	metre (m)	9.144 × 10⁻¹
yard³/short ton	metre³/kilogram (m³/kg)	8.428 × 10⁻⁴

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